Human Fertility and Fitness Optimization

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Census and other survey data from across the world reveal major differences in fertility rates between the more economically developed and the less economically developed societies The former are significantly more likely than the latter to feature families of two children or fewer Multiple regression analysis shows that, among various indicators of "modernization," three (female level of education, female gainful employment, and proportion of physicians in the population) account for 71% of the variation in family size, all three variables have strongly significant, direct, and negative effects on fertility The paper hypothesizes about the possible evolution of a reproductive psychology toward the two-child family and seeks to explain highly depressed rates of reproduction by reference to both ultimate and proximate factors In some highly developed countries, zero-child and one-child rates of fertility represent together up to 40% of all ever-married women. The findings stress the importance of systematic research toward establishing the proximate factors that are most likely to facilitate or impede fitness optimization—the importance, that is, of surrounding the optimization principle with the logic and ancillary propositions that will give it a greater and more directive reach

KEY WORDS Fertility Modernization Evolution of family patterns Natural selection Fitness optimization Family Women

INTRODUCTION

Evolutionary behavioral science is still young, but in one respect it is already reaching for advanced status and may be said to bear to Darwinian theory a relationship analogous to that of relativity theory to celestial mechanics Each helps to explicate the paradigm mechanism of the predecessor

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The effort to behaviorally explicate natural selection is epitomized by the Optimization or Maximization Principle, which in its least problematic form states that organisms tend to behave so as to maximize the probability of safeguarding their inclusive fitness (Hamilton 1964, Trivers 1971, 1985, Alexander 1975, Wilson 1975 1978 Dawkins 1982, van den Berghe 1978 Durham 1979, Irons 1979 Lumsden and Wilson, 1981, Barash 1982, Shepher 1983, Lopreato 1984)

This proposition is integral to the semantics of the natural selection mechanism by virtue of its linkage to the Malthusian–Darwinian struggle for existence" that inspired the conception of the mechanism in the first place On the whole it is also founded on fairly solid bases For example there is a vast literature showing that organisms compete for reproductive success and, in social relations, favor kin and reciprocators

It is essential, however, to avoid the temptation to take adaptive behavior as axiomatic The optimization principle asserts merely a genetically programmed *tendency* The translation of predisposition into action is a function of the variable intensity of the predisposition and of the environmental parameters with which it interacts The logic of this proposition is basic to evolutionary biology, wherein adaptation has sometimes been explicitly defined as the functional interdependence of organism and environment" (Simpson 1949) Programmatically, the logic requires the systematic search for the proximate conditions that interact with the optimization tendency In this sense the optimization principle is remarkably promising but still understandably deficient It will have reached its full-fledged paradigmatic status when evolutionists will no longer have to make the relatively desultory recourse to 'tendency" and will state the principle in a form more akin to a proposition like the following *Organisms behave so as to optimize their inclusive fitness, provided that conditions a, b, c n obtain*

The failure to ' idealize" the principle and take systematic steps to surround it with the needed empirical qualifiers sometimes leads to seemingly over-adaptationist" statements (Alexander 1975) Perhaps worse, at least insofar as interdisciplinary discourse is concerned, it leads critics to misconceive the intrinsic logic and heuristic value of the principle (Vining 1986)

The fundamental measure of adaptiveness is reproductive behavior Accordingly, we shall focus in this paper on demographic data, crucial to sociobiology and yet still underutilized Our principal goal is to consider some proximate factors that in different degrees react on the tendency toward adaptive behavior We wish to stress in this connection that, although we are committed to the proposition that human behavior is, in rare cases thoroughly maladaptive (Lopreato 1984) our intention is to lend support to the contingent or conditioned validity and the heuristic import of the optimization principle, not to question them

HUMAN FERTILITY: A BIOCULTURAL ANALYSIS

Studies of human fertility, including foci on the one-child and the childless families, abound (United Nations 1973, Veevers 1973, Blake 1974, 1981, Hastings and Robinson 1974, Poston 1976, Tsui and Bogue 1978, Housekenecht 1982, Pankhurst 1982, Poston and Trent 1982, Coale 1983 Poston and Kramer 1983) Upon scrutiny, however, the typical approach is either almost purely descriptive, or, removed as it is from an evolutionary perspective in an area that is eminently evolutionary in nature, it is often manifestly specious

Measurement and Data

Most of our subjects refer to ever-married women (EMW) from 63 countries and areas (hereafter referred to simply as "countries" or "societies") The data refer only whenever possible and/or advisable to women in the 45–49 age bracket, by that age, it is generally agreed that with few exceptions the reproductive cycle has come to an end For most countries, the category "ever-married women" includes all women who were married, widowed, divorced, or separated, for a few countries, data is available for married women only The data was obtained from national censuses, United Nations Demographic Yearbooks, and, in a few instances, from the World Fertility Surveys or Demographic Reports

Findings

Table 1 shows for each of the 63 countries and for years varying between 1970 and 1981 the percentage of women who had zero, one, two, or three or more live births, a widely used measure of fertility among demographers Rates, or "parities," vary widely In general, however, a high proportion of the highest parity, along with a low proportion of one-child and zero-child parities, is associated with a low level of socioeconomic development Thus, in such countries as Colombia, Egypt, Ghana, Guatemala, Kenya, and Syria, the number of women giving birth to three live children or more approximates 90% of the total, while the one-child and the childless parities together fall only in the 4–8% range

Conversely, as the level of socioeconomic development rises, the frequency of the higher parities decreases drastically, while the reverse is true with respect to the one-child and childless rates In such countries as Belgium, Czechoslovakia, the two Germanies, Hungary, Luxemburg, and the United Kingdom, the highest parity ranges between 26 and 37 percent, while the childless and one-child rates together range between nearly one-third and more than two-fifths of the total More salient in these societies is also

Table 1 Percentage of Ever-Married Women (EMW)[a]

Country or area	Year	% of EMW with no. of live births				Mean no. of live births per EMW
		0	1	2	3 or more	
Argentina	1970	6.5	18.4	30.0	45.1	3.1
Australia	1976	9.4	9.1	25.4	56.1	3.0
Bangladesh	1974	10.4	2.9	4.4	82.3	5.9
Barbados[c]	1970	11.6	10.9	12.0	65.5	4.6
Belgium	1970	19.3	23.9	22.6	34.2	2.2
Belize[c]	1970	7.0	7.0	9.8	76.2	6.4
Brazil	1970	6.8	7.3	10.3	75.6	6.4
Bulgaria	1975	4.4	23.5	51.6	20.5	2.1
Canada	1981	7.2	9.0	22.9	60.9	3.3
Chile	1970	12.7	7.1	10.2	70.0	5.1
Colombia	1976	2.4	3.5	4.3	89.8	7.3
Costa Rica	1976	3.6	3.6	5.5	87.3	7.2
Cyprus[d]	1973	5.3	6.4	17.9	70.4	3.9
Czechoslovakia	1970	11.1	17.0	34.5	37.4	2.4
Dominican Rep	1976	3.6	7.1	5.8	83.5	6.8
Egypt	1980	3.7	4.1	4.2	88.0	6.9
Fiji	1974	6.8	4.3	5.0	83.9	6.6
Germany, East[e]	1971	19.1	25.6	28.9	26.4	1.9
Germany, West	1970	15.6	27.1	29.3	28.0	1.9
Ghana	1979–80	2.1	2.1	4.6	91.2	6.7
Grenada[c]	1970	8.4	8.1	7.8	75.7	5.5
Guatemala	1973	2.6	3.9	5.9	87.6	6.9
Guyana[b]	1970	6.9	6.7	7.0	79.4	6.2
Haiti	1977	2.1	5.9	4.2	87.8	6.1
Hong Kong	1976	4.0	8.6	10.9	76.5	4.4
Hungary	1970	10.8	23.7	32.3	33.2	2.1
Indonesia	1976	8.4	8.0	9.0	74.6	5.3
Italy	1979	5.7	16.8	37.4	40.1	2.5
Ivory Coast	1980–81	5.0	4.3	4.8	85.9	6.9
Jamaica	1970	11.3	11.4	10.4	66.9	4.8
Japan	1970	9.4	11.1	23.8	55.7	2.8
Jordan	1976	2.3	1.2	1.1	95.4	8.8
Kenya	1977–78	2.8	2.1	2.5	92.6	7.9
Korea (South)	1980	1.5	3.7	6.4	88.4	4.7
Kuwait	1975	5.8	5.0	6.8	82.4	6.1
Lesotho	1977	4.1	7.2	9.3	79.4	5.4
Libya	1975	4.5	2.1	2.6	90.8	7.7
Luxemburg	1970	13.2	27.5	29.8	29.5	2.0
Malaysia	1980	2.2	4.3	7.2	86.3	5.7
Morocco	1979–80	8.5	4.3	4.3	82.9	7.1
Mozambique	1970	16.2	8.7	10.2	64.9	4.3
Nepal	1976	4.5	5.5	7.6	84.4	5.7
New Zealand	1981	6.7	6.1	21.3	65.9	3.4
Pakistan	1975	5.0	3.7	5.7	85.6	5.6
Panama	1970	5.5	6.9	9.6	78.0	5.5
Paraguay	1979	2.5	5.8	7.7	84.0	6.5
Peru	1972	11.7	3.2	4.8	80.3	6.4
Philippines	1970	5.9	7.3	9.2	78.6	5.4
Poland	1970	6.4	11.8	23.8	58.0	3.1
Portugal	1970	9.4	20.4	22.4	47.8	3.2
Puerto Rico	1970	6.8	9.5	17.3	66.4	4.6
Singapore	1980	2.4	5.7	10.9	81.0	4.9
Spain	1977	5.8	10.8	25.9	57.5	3.1
Sri Lanka	1971	12.8	4.5	6.2	76.5	6.0
Sudan	1979	8.6	4.9	6.6	79.9	6.0
Syria	1970	4.3	1.9	2.5	91.3	8.0

Table 1 *(Continued)*

Country or area	Year	% of EMW with no. of live births				Mean no. of live births per EMW
		0	1	2	3 or more	
Taiwan	1980	2.1	2.9	6.5	88.5	4.5
Thailand	1980	2.8	4.6	7.0	85.6	6.3
Trinidad and Tobago[a]	1970	9.6	9.2	8.7	72.5	5.5
Turkey	1975	5.6	4.4	8.0	82.0	5.5
United Kingdom	1971	12.4	23.2	31.4	33.0	2.2
United States	1980	7.7	10.4	22.1	59.8	3.2
Venezuela[c]	1977	2.0	4.4	10.2	83.4	6.3
Mean for All Countries		7.1	9.0	13.5	70.4	5.0
Mean for 17 MDCs		10.2	17.5	28.5	43.8	2.6[d]
Mean for 46 LDCs		5.9	5.8	7.9	80.3	5.9[d]

Source: Data are from national censuses or fertility surveys.

[a] Aged 45–49 with given numbers of live births for 63 countries and areas, 1970–1981.

[b] Refer to women who are not attending school.

[c] Different age categories: Chile and Panama, 40–49; Egypt, Ghana, Haiti, Ivory Coast, Jordan, Lesotho, Morocco, Nepal, and Sudan, 45 and over; Italy and Venezuela, 40–44.

[d] Refer to married women only.

[e] The difference of means test indicates that there is a significant difference between the means of MDCs and LDCs.

the two-child family,[1] which accounts for approximately 30 percent of all families.

The above differences may be grasped at a glance by focusing on the fertility means. Table 1 provides the means of each country, the means for all countries, and the means for the 63 countries divided into the two categories of *more developed* (MDC) and *less developed* (LDC) according to United Nations practice[2] (Population Reference Bureau 1985). Note that the mean fertility rate for the LDCs is more than double its counterpart among the MDCs; the latter have higher means for all parities except the highest, while the opposite, by a large margin, holds true for the less developed countries.

A multiplicity of economic, social, and cultural factors may be proximate determinants of fertility levels and variations (United Nations 1973, Tsui and Bogue 1978, Ross 1982), and the transformation of the family in response to modernization is treated at some length in the literature (Goode 1970, Huber 1973, Mott 1982). It is generally acknowledged that there is an inverse relationship between family size and modernization. Accordingly, we shall proceed with a multiple regression analysis with a view to isolating specific factors that represent the process of modernization.

Our dependent variable is the mean number of live births per ever-

[1] For convenience sake, we may occasionally speak of families, but this terminology is not strictly warranted.

[2] The MDCs comprise all of Europe, the U.S.S.R., the United States, Canada, Japan, New Zealand, and Australia. All other countries are classified as LDCs. The classification is largely intuitive. The indicators in our Table 2, however, explicate the U.N. guidelines to some extent.

Table 2 Mean Values for the Indicators of Modernization Used in the Study

Indicators of modernization	Mean for all countries	Mean for 17 MDCs	Mean for 46 LDCs
GNP per capita (U S $)	708 8	1511 2	412 3
Urban population (% of total)	45 5	65 5	38 1
% Female adults literate	63 9	89 5	54 4
% Women in total labor force	28 6	39 0	24 8
Life expectancy at birth (years)	61 9	70 7	58 6
Infant survivorship rate[a]	938 3	974 9	924 8
Physicians (per 10 000 persons)	7 2	14 9	4 3
% Women aged 15–49 in family union using contraception	37 7	64 5	27 8

[a] Number of survivors under one year of age per 1 000 live births

married woman aged 45–49 The independent variables are eight indicators of modernization" GNP per capita (U S $), urban population (% of total), % female adults literate % women in the labor force, life expectancy at birth (years), infant survivorship rate (number of survivors under 1 year of age per 1,000 live births), physicians per 10,000 persons, and percentage of women aged 15–49 in family union using contraceptives Of the eight indicators, four (GNP per capita, urban population, women literate and women in the labor force) are intended to reflect level of socioeconomic development The other four indicate the health conditions of countries Our choice of indicators was motivated by their widespread use in the modernization literature We turn first to differences on the indicators between types of society

Variations between the two types of societies assume major proportions (Table 2) Women in the less-developed societies are on the average much poorer much more apt to live in rural areas much more likely to be illiterate, and less likely to be engaged in gainful employment—a factor that appears to reduce fertility universally (United Nations 1973) The greater fertility of women in the poorer countries is also associated with factors that directly concern reproduction and survival chances Thus, such women are almost four times less likely to have access to a physician their babies are more often stillborn and life expectancy at birth is 12 years shorter in their countries than it is in the richer countries (World Bank 1984) These factors, in turn, help to explain the much rarer use of contraceptives by the poorer women during their reproductive years (ages 15–49) Clearly in order to obey the optimization principle, they have to work harder in the reproductive competition

The regression analysis shows further that the indicators of modernization are all positively and, with few exceptions, significantly intercorrelated The findings, in short, suggest that industrialization and urbanization are accompanied by an increase in women's education and gainful employment and by such improvements in health conditions as easier access to physicians and a higher probability of infant survival These factors then

Table 3 Stepwise Multiple Regression Predicting the Mean Number of Live Births per Ever-Married Woman, Aged 45–49

Independent Variable	Standardized coefficient	Significance
Physicians (per 10 000 persons)	− 56	000
Women in total labor force (%)	− 21	011
% Female adults literate	− 24	016
Multiple R	84	
R Square (% of variance explained)	71	
% Physicians per 10 000 persons	63	
% Women in labor force	27	
% Female adults literate	45	

may be viewed as providing strong motivation for women to limit their fertility We shall return to the rationale behind this last statement in the section on the two-child family For the moment, we may add that the strongest correlations involve female literacy and all four indicators of health conditions

These high correlations, which we have not shown in tabular form for considerations of space, cannot, however, be taken at face value due to the likelihood of collinearity Indeed, a stepwise multiple regression analysis (Table 3) shows that only two indicators of socioeconomic development (females in the labor force, female literacy) and one indicator of health conditions (number of physicians) have direct, negative, and significant effects on the mean number of live births, our measure of fertility About 71% of the variation in family size is explained by these three variables

Further regression analysis, using the four indicators of socioeconomic development as independent variables and the number of physicians as a dependent variable, demonstrates that all four independent variables are significantly and positively related to the dependent variable Hence, all four indicators of socioeconomic development have direct and/or indirect effects on fertility via the availability of physicians

Our major findings, summarized in Figure 1 may be stated as follows (1) Women's gainful employment and educational level have strong *direct*, negative, and significant effects on the number of live children they bear, (2) the number of physicians is the only indicator of health conditions that is significantly and negatively associated with family size, and (3) all four indicators of socioeconomic development have fertility effects that are mediated by the number of physicians Apparently, the availability of physicians is perceived as good insurance that children will survive and be healthy

Education and Fertility

The literature in behavioral science amply demonstrates that there is an economic" dimension to animal behavior—that activity may fruitfully be viewed as the outcome of a cost-benefit analysis From this perspective, the

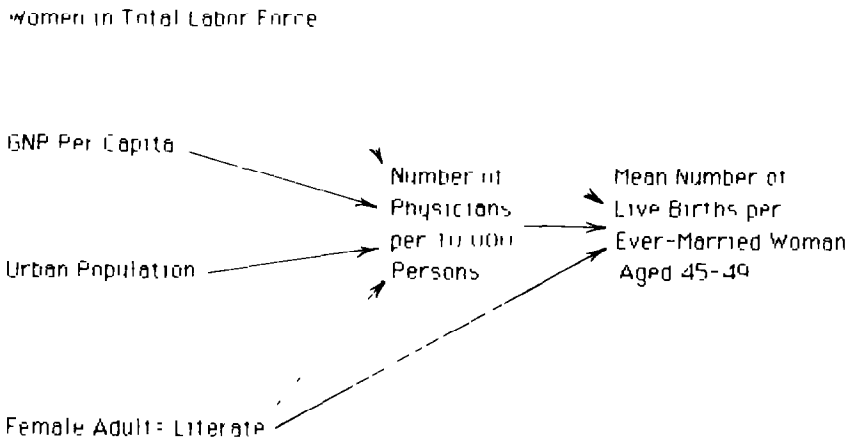

FIGURE 1 Significant effects of independent variables on the number of live births per ever-married woman aged 45–49

direct and negative correlation existing between education and fertility looms especially important Of all relevant factors educational level is probably the best measure of the individual s capacity to deliberate about the costs and benefits of activity reproduction included Focused attention to education is thus warranted Unfortunately information on women s education at the level of our sampling is available only from very few countries Table 4 reports data on four Canada and the United States as representatives of the more developed societies and Hong Kong and Singapore as representatives of the less developed societies Education categories are shown as in the original sources and arranged so as to facilitate cross-country comparisons

The table shows as expected that the probability of mothering fewer than three children increases directly with education Conversely a family of three or more offspring becomes less likely as the level of education increases Associated with these findings is the fact that the two-child family becomes more common as the educational level rises

Some noteworthy differences remain between the two types of countries despite the control for education For instance among the most educated the one-child and childless rates are less common in the less developed than in the more developed societies At the other extreme among the least educated the highest parity is less likely in the more-developed than in the less-developed societies Nevertheless the effect of education remains very strong Indeed its power is most apparent in the less-developed societies where universal-education policies are usually lacking and intrasocietal educational differences are most marked Thus the difference on the highest parity between the least-educated and the most-educated is much more conspicuous within the less than within the more-developed countries

Proximate factors then play an important role in reproductive patterns

Table 4 **Percentage of Ever-Married Women (EMW), Aged 45–49, with Given Numbers of Live Births, by Educational Attainment, in Canada, Hong Kong Singapore, and the United States**

Canada 1981

Educational attainment	Total EMW	Percentage of EMW with given numbers of live births				
		0	1	2	3 or more	Total
Less than 9 grades	163 560	5 7	8 3	19 2	66 7	99 9
Grades 9–13	247 230	6 7	8 8	22 9	61 7	100 1
Some university or similar	43 420	8 2	9 4	26 2	56 2	100 0
Other nonuniversity certificate	92 715	8 5	10 1	25 7	55 7	100 0
University certificate or degree	38 240	12 4	10 3	28 0	49 4	100 1

Source All data for Table 4 is adapted from the latest national censuses

Chi square = 6 826 1 with 12 degrees of freedom significance = 0000

Hong Kong 1976

Educational attainment	Total EMW	Percentage of EMW with given numbers of live births				
		0	1	2	3 or more	Total
No school	56 150	3 3	7 9	8 4	80 4	100 0
Primary	40 160	4 3	8 7	11 8	75 3	100 1
Secondary	11 910	6 5	11 1	18 0	64 4	100 0
University	1 160	7 8	12 9	29 3	50 0	100 0

Chi square = 2 169 8 with 9 degrees of freedom significance = 0000

Singapore 1980

Educational attainment	Total EMW	Percentage of EMW with given numbers of live births				
		0	1	2	3 or more	Total
No qualification	37 976	2 1	4 6	7 8	85 5	100 0
Primary	9 182	2 7	8 5	16 8	72 0	100 0
Secondary and upper secondary	2 581	4 7	11 5	30 8	53 0	100 0
Tertiary	433	4 6	9 2	38 3	47 8	99 9

Chi square = 2 803 6 with 9 degrees of freedom significance = 0000

United States 1970

Educational attainment	Total EMW	Percentage of EMW with given numbers of live births				
		0	1	2	3 or more	Total
None	37 279	13 3	10 9	15 3	60 5	100 0
Elementary 1–8 yrs	1 121 551	11 3	13 6	19 3	55 9	100 1
High school 1–4 yrs	3 747 206	10 4	14 8	27 2	47 7	100 1
College 1+ yrs	1 014 593	11 7	13 4	28 5	46 5	100 1

Chi square = 42 450 7 with 9 degrees of freedom significance = 0000

and appear to have a significant effect on the tendency toward fitness optimization This finding, as already noted, is entirely in keeping with sociobiological science, which emphasizes the interdependence of genetic and environmental factors Our findings, however do present us with an apparent paradox In three of the four countries in Table 4, a rise in educational

level suggests a tendency to balance the costs and benefits of reproduction at the expense of reproduction To be sure, the proposition that culture is adaptive is not a dogma in sociobiology But neither is it theoretically feasible to depart greatly from it Thus, on the surface at least the inverse relation observed between education and fertility would seem to be a bit irregular We shall return to this context in the section on depressed rates of reproduction

THE TWO-CHILD FAMILY

Our focus for the moment will shift to one of our more common findings, namely, to the fact that in most countries the two-child represents the second-largest family size (in view of our four fertility categories) *and* that this parity increases rather dramatically as we approach the more developed societies (as shown in Table 1 from a mean of 7 9% to one of 28 5%) In fact, in some developed countries (e g Czechoslovakia, Finland, the two Germanies, Hungary, Italy, Luxemburg, and England–Wales) the two-child family is the most common—in some cases by a fair margin, as a more detailed division into fertility rates could easily show

What is the meaning of this compelling finding? Is it not possible that *Homo sapiens* has been evolving toward the two-child family? The idea is worth considering, however speculatively We have keen awareness of unbridled conjecturing But we are equally aware that a discipline like astronomy indeed science as a whole, is fueled to a large extent exactly by speculation Francis Bacon's dictum still holds Conceive the improbable!

In point of fact we think that our hunch is not very improbable Consider briefly our demographic history There is reason to believe that births and deaths in the societies of preagrarian times were roughly in equilibrium To be sure, there were periods and places of explosive population growth, no doubt associated with technological revolutions, *inter alia* (United Nations 1953) But even the typical agricultural society of pre-Industrial Revolution time existed at a high degree of demographic stability, probably doubling in size over extended periods of time According to the best estimates of world population, as recently as 1650 A D humans numbered about one-half billion (United Nations 1953), compared to approximately 5 billion today (Population Reference Bureau 1986) At the same time fertility rates were very high It follows that on the average, little more than two out of many children per family survived to reproductive age We may stretch the point somewhat and say that under the then-existing conditions of high mortality, women had so many children in order that at least two might survive

This ancient human experience suggests the possibility that the human psychology has been evolving toward a reproductive strategy that adjusts optimal genetic benefit to minimal cost and that the hypothesized tendency toward the two-child family of modern societies is ultimately the result of

this evolution This reasoning may seem contrary to sociobiological theory It would appear to require proof that, as a reader of an earlier version of this paper suggested, more than two children per woman would be less advantageous in terms of inclusive fitness " We would hardly wish to adhere to any such statement, although, since natural selection operates over the long run," in the course of three or more generations the fitness of a three-offspring parent may and often does end by being lower than the fitness of a corresponding individual bearing only two children

But we need not worry about such proof Speaking strictly, in terms of the logic of natural selection the issue here at stake concerns the number of children an individual has *in comparison to others in the population* Consider a hypothetical society in which, say, 70% of the women produce two offspring each, while the remainder divide more or less evenly between zero reproduction, one-child reproduction, and three-child reproduction In such a society, fairly approximated by some societies at present, the adaptiveness of the two-child strategy is higher than average and could be the most adaptive in many individual cases

Our hypothesis of evolution toward a two-child reproductive psychology would be theoretically untenable only if it were intended to apply to an entire breeding population—that is, if it denied differential reproduction But that is not our intention When viewed through the perspective of a bell curve, our suggestion is merely that we may be experiencing *a sort of stabilizing selection* around the surviving median of the evolutionary past, without implying that the tails have disappeared altogether What demographers have termed the "demographic transition"—namely, a period in which demographic equilibrium at a high rate of both fertility and mortality is followed, first by reduced mortality and increased population growth and then by restored equilibrium at a lowered rate of both fertility and mortality—appears to mark a relatively high point in the evolution of the two-child family

In speculating in favor of a two-child psychology, we do not, moreover, intend to argue that people in principle would not rather have more children We propose merely that humans have had to survive in a costly environment, and some family planning further in the direction of K-selection has been favored by various factors for instance, warfare (Davie 1929, Turney-High 1949), periodic scarcity of food, disease exacerbated by malnutrition, spontaneous and willful abortion (Devereux 1976), and infanticide

Concerning the latter, for example, one survey showed that it was practiced in 80 of 86 recent societies examined (Divale 1972, Harris 1974) There is, of course, considerable controversy about the frequency and causes of infanticide The practice is rarely recorded, and must therefore be derived from hearsay and the personal experiences of individuals who are interviewed with varying degrees of reliability (Hausfater and Hrdy 1984) There is some agreement on the proposition that the ultimate cause of infanticide is parental manipulation, an adaptive strategy that is typically activated by

the necessity to eliminate defective offspring (Whiting et al 1977) and to practice the birth spacing required by scarce resources (Howell 1976 Alexander 1979 Daly and Wilson 1984) But at present it seems impossible to conclusively embrace the hypothesis of fitness enhancement over others—for example over one that stresses the mothers efforts to maintain their own quality of life (Hausfater and Hrdy 1984 Scrimshaw 1984) (for an update of the state of the art on infanticide see the papers in Hausfater and Hrdy [1984])

Pursuing further elements of our demographic history it appears that the agrarian revolution favored a larger family possibly due to the often alleged economic asset of children although many scholars doubt the validity of an economic evaluation of offspring Suffice it to note that agrarian families have been burdened by the demands of expensive dowries and or bride prices (Lopreato 1967 Irons 1975) Indeed the lot of the peasant has been horrendous by nearly all accounts (Douglas 1894 Lewis 1966) Nevertheless population checks did abate somewhat in agrarian society at least among the economically more viable social strata But in view of the previously noted estimates of world population growth the increase in fertility was necessarily modest

The economic value of the child if it ever was real was lost with the rise of industrial society and such associated practices as universal education and the extended period of socialization and child dependency (United Nations 1973 Davis 1982) Infanticide never abandoned, has been largely replaced by more efficient means of contraception and to an extent by increased rates of abortion As a result the population of advanced industrial society is closer to the near-equilibrium of the typical hunting and gathering society The phenomenon is not entirely surprising in view of the circumstances of human demographic history as we know it The human population of today descends from people who over long periods of time made reproductive adjustments to Malthusian checks in the direction of what was essentially a two-child family

In all likelihood the two-child psychology if real is still evolving in view of persisting impediments to reliable family planning in much of the world Hence the three-child family is still very common Still as environmental conditions (socioeconomic medical etc) change so that *if two children are produced both survive the probability of the two-child family is likely to increase* Little wonder that as already noted in many advanced societies the two-child parity represents the modal family (Table 1) Moreover studies from the United States show that having two children is typically considered ideal and a preference for such parity has been steadily increasing through the years (National Opinion Research Center 1984)

There are a few irregularities in our findings One concerns the fact that the inverse correlation between socioeconomic development and fertility is imperfectly linear For example the United States certainly one of the most developed economies features relatively low rates of depressed

fertility Doubtless, there are subclasses of proximate factors that help to explain variations within each of our two types of societies (for examples of fertility cycles in the United States over the past century, see Pullum [1980, in press]) We cannot go into what would surely be a very complex and lengthy analysis, we may rest satisfied with the very pronounced differences existing between the more advanced societies taken as a whole and the less developed countries also taken as a unit The polarity is hardly questionable

Another finding, however, cannot be disposed of so easily As we have noted in Table 1, a certain percentage of women in all societies have had only one child or none at all These two fertility categories combined amount to between 4–8% for such countries as Colombia, Ghana, Jordan, South Korea, Syria, and Thailand, and 40% or more for such more developed countries as Belgium, Czechoslovakia, Findland, Luxemburg, and the two Germanies

DEPRESSED RATES OF REPRODUCTION

How do we explain such widespread rates of depressed reproduction in the more developed societies, and among the best educated in general? The problem is eminently complex The following comments are offered only as a rough approximation to a plausible answer Let us note first that if we conceptualize a reproductive norm, for example, a historical trend toward the two-child family the mechanistic logic of natural selection predicts that on the basis of chance factors alone, some individuals will overshoot the norm while others will fall short of it

More specific factors can be adduced however to support our effort Consider, for example, that for a complex set of causes, divorce opportunities and rates have been on the increase in recent times This development has taken place *pari passu* with a tendency to delay marriage and/or parenthood because of economic, occupational, and various other considerations (Cohen 1974, Fisher 1974) Such behavior tends to depress fertility chances, for beyond a certain point fecundity decreases with an increase in the age at marriage, and many women are left without husbands while still in the peak years of their reproductive life (Van den Berg and Oeschsli 1980, Grimstaff et al 1981)

The Role of Creature Comforts

The above may be viewed as largely chance factors in the depression of fertility rates—as factors having the unintended consequence of a low reproductive rate In view of Table 4, it may be useful to say otherwise that they are probably filtered through formal education to produce what seems a maladaptive effect This negative correlation between formal education

and fertility very likely confirms the Darwinian hypothesis and some social theory that the probability of normal, if not adaptive, behavior decreases in proportion as instinct gives way to "reason" (Darwin 1872) (for social science, see Durkheim 1897 1912, Pareto 1916, Freud 1930, Mead 1934)

In short, the large and systematic differences in fertility rates existing between the more developed and the less developed countries and between the more and less educated women, suggest the idea of a degree of voluntarism in depressed reproductive behavior Indeed, a number of studies have shown fairly conclusively that a certain percentage of married women deliberately avoid parenthood altogether, while biologically capable of motherhood, for example, they report both a desire to avoid parenthood and the use of contraceptives even as they are approaching the menopause (Blake 1974, Baum 1980, Feldman 1981, Houseknecht 1982) (for a discussion of methods assessing voluntary childlessness, see Poston and Kramer 1983)

There is much self-deception in human behavior, and consequently it is quite probable that available estimates tend to inflate the voluntary rates of childless and one-child fertility Thus, upon close examination, the voluntary childless rate for the United States, for example, is probably no higher than 2 6% among women in family union (Poston 1976, Lopreato 1984) Still, it is not inconsiderable, and the voluntary one-child rate is no doubt much higher Collapsing the two parities into one, we may now ask what willful factors are likely to enter the cost–benefit analysis of reproduction to depress fertility to that extent?

Any attempt at a detailed answer would require consideration of multiple factors pertaining at least to the changing family and changing women in modern societies (Goode 1970, Huber 1973, Dawson Scanzoni and Scanzoni 1981, Hutter 1981, Wandersee 1981, Deckard 1983) Viewed as purposive agents, most of them are, however, usefully reducible to a proximate mechanism of biocultural evolution that has received some theoretical attention at least since the time of Charles Darwin and Herbert Spencer Thus Darwin's principle of the so-called serviceable associated habits" acknowledges a bias, more or less willful, toward the execution of activities that are of 'direct or indirect service under certain states of the mind, in order to relieve or gratify certain sensations, desires, etc '

Working within this tradition, some students of biocultural evolution have recently given primacy to such mechanisms as struggle for satisfaction" (Ruyle 1973) and struggle for satisfaction or reinforcement ' (Langton 1979) stressing that people struggle in their physical and social environments to satisfy their daily needs and wants, including what some scholars have termed creature comforts "

Another argument (Lopreato 1984) maintains that biocultural evolution is ultimately the result of an interplay between predispositions of variation and predispositions of selective retention The interplay is guided by such selection criteria" as creature comforts, fitness optimization, and systemic immanence Further the evolution of consciousness and culture has accen-

tuated the search for creature comforts, as attested by the enormous improvements in shelter, work technology, transportation, prophylaxis, and recreation, *inter alia*

The conceptualization of creature comforts as a criterion of selection in the evolution of behavior is in all likelihood based on solid grounds As has often been noted, organisms are better adapted to past conditions than to present and future ones The circumstance underscores the element of risk involved in the acceptance of behavioral novelties *and* the likely evolution of criteria that specialize in an early testing and screening of the novelties The criterion of creature comforts very probably represents one such device, pleasure is its metric

The bias in favor of pleasure stimulates a variety of behaviors Our intention is to be illustrative and plausible, not exhaustive First for our purposes is a sense of personal comfort that is best defined in terms of *freedom to do*, and is closely associated with a *sense of aesthetics* Regardless of the public services available for child care, children tie modern women down, if not during the day, then in the evening when the freedom to do can be experienced in various types of recreation, including sexual activity without the responsibility of motherhood Moreover, the freedom to do—the freedom to be a woman and not, or not just, a mother—demands that she present the most obvious phenotypical attractions as her chief credentials What Immanuel Kant termed the conception of the beautiful and sublime has become an obsession in modern society and made very stringent demands on women To be beautiful requires time and money as well as natural endowments Children take away from both at the same time that they sometimes exact a heavy toll on the aesthetics of the body For example, a "thirty-ish" fashion model may wish to mother a child, but her family has a history of unaesthetic" incidents associated with pregnancy at this age, and she chooses to forgo motherhood

The fewer the children, the greater the amount of leisure time available to the mother not only in the course of a day but also in the course of a lifetime That is, the sense of personal comfort underscores the import of one's future years Giving birth to one child at around the age of 25, for example, effectively frees the mother of babysitting obligations by the age of 37–38, when she feels still young and attractive enough to enjoy the hobbies and entertainment earned with her hard work Conversely, given a large family, she is often called upon to be her children's babysitter at just about the time when she would be free to enjoy life at leisure

This argument does not gainsay the fact that bearing children can be and often is a creature comfort in itself There are profound emotional rewards to having children and experiencing their development Natural selection did not entrust reproduction to chance factors, the pleasure of motherhood may be viewed as insurance of sorts for reproductive activity We are merely saying that benefits are balanced against each other, just as costs

and benefits are and sometimes the pleasure of motherhood or further mothering yields to other sorts of pleasure

Second the one-child family is advantageous in some adult psychologies to the child as well as the parent for the one child may be showered with personal attention and valuable material resources (Blake 1981 Ching 1982) There is some sophistry in this reasoning but it is probably true also that in some cases a certain degree of long-range fitness is recovered through such a strategy

Third the need for creature comforts may underlie the desire to compete and achieve in (seemingly or truly) advantageous areas from which women have traditionally been excluded There is some evidence to indicate however, that the greater the job success of women the greater the probability of childlessness (United Nations 1973) Census data in the United States shows that as many as 60% of executive women are childless It would thus seem that faced with the option of choosing between the benefits of making it in a man s world and the benefits of motherhood some women choose to avoid motherhood altogether

Fourth and for brevity s sake finally, an animal endowed with an extraordinary degree of consciousness may occasionally be expected to counteract the optimization tendency with a crippling fear that to be—to exist—is simply not a desirable state of affairs There is no hard evidence in favor of this idea But the phenomenon of suicide of late much on the rise is certainly suggestive Equally suggestive is the widespread pessimism about a future rendered intolerably oppressive by the constant threat of doomsday weapons When hope for the future is undermined by unending fear, some people may simply lose the desire to bear children into that future—or a least become subject to debilitating ambivalence Great writers of acutely fateful historical junctures have often noted the phenomenon A character in Dickens *A Tale of Two Cities* for instance, states I say we were so robbed and hunted and were made so poor that our father told us it was a dreadful thing to bring a child into the world and that what we should most pray for was that our women might be barren and our miserable race die out!

FERTILITY AND KIN SELECTION

We may thus have isolated some factors that tend to reduce adaptive behavior Our confidence in such findings, however must be restrained at least until we shall have effected an important control The optimization principle makes specific reference to *inclusive* fitness which recommends an examination of kin selection Such information is scarce but fortunately not entirely unattainable For instance according to a recent study from greater Los Angeles California childless women were more diligent than parental women in catering to the needs (giving help) of nieces and neph-

Table 5 Number of Siblings by Number of Live Births Among Ever-Married U S Women, 1984

	Number of live births (%)			
Number of siblings	0	1	2	3 or more
Ages 15–49[a]				
0	6 (8 5)	5 (5 5)	5 (3 8)	2 (1 5)
1	17 (23 9)	15 (16 5)	20 (15 2)	22 (16 1)
2	14 (19 7)	19 (20 9)	26 (19 7)	23 (16 8)
3 or more	34 (47 9)	52 (57 1)	81 (61 4)	90 (65 7)
Total	71 (100 0)	91 (100 0)	132 (100 1)	137 (100 1)
Ages 50 and over[b]				
0	1 (2 6)	1 (2 0)	4 (7 1)	7 (4 6)
1	5 (12 8)	9 (18 0)	6 (10 7)	14 (9 2)
2	6 (15 4)	6 (12 0)	8 (14 3)	17 (11 1)
3 or more	27 (69 2)	34 (68 0)	38 (67 9)	115 (75 2)
Total	39 (100 0)	50 (100 0)	56 (100 0)	153 (100 1)

Source Adapted from National Opinion Research Center (1984)

[a] Pearson s R = 0 14358 significance = 0 001

[b] Pearson s R = 0 03951 significance = 0 248

ews (Essock-Vitale and McGuire 1985b) This finding would seem to provide some support for the idea that some units of fitness in our low-fertility subjects were recovered through kin selection The same authors however, show that never-married subjects (a small subsample N = 17/300) had fewer sibs, fewer children, and fewer nieces and nephews than ever-married subjects (Essock-Vitale and McGuire 1985a)

Our own data on kin selection are shown in Table 5, which reports information from a 1984 U S national sample of ever-married women carried out by the National Opinion Research Center (1984) The findings reveal for all ages a significant and positive correlation between the number of children born to ever-married women and the number of the latter s siblings The case of the younger sample is exceptionally clear Nonreproductive women are the most likely to have neither brothers nor sisters and the least likely to have three or more siblings Conversely, the most reproductive women are the least likely to have no siblings and the most likely to have three or more The older sample presents a less linear picture, but here, too, with few exceptions, the most reproductively successful women were born into the most reproductive families

Thus, in the United States at least, low-fertility women were brought up in low-fertility families kin selection is not likely to have substituted for individual selection We rather suspect that fertility patterns are the result of inheritance as well as learned behavior, but this hypothesis is a by-product of our discussion, not a part of our research intention

CONCLUSION

As social scientists eager for a general theoretical anchor endowed with a nomothetic cast we are hardly inclined to interpret our findings as a grave

challenge to the optimization principle At the same time we are keen to the possibility that the evolution of consciousness and culture has imposed some weighty constraints on the optimization tendency *They should be known through systematic study* Our paper is presented as a modest contribution to this effort

As presently stated the optimization principle appears to fail in the crucial respect of not demanding from the community of scientists focused and cumulative research on the factors that facilitate or, conversely, inhibit optimization predispositions The quest for such empirical qualifiers is not only recommended by the extraordinarily fruitful use made of theoretical idealizations' in the older sciences (e g of Newtonian laws) It is also demanded by the requirements of a biocultural science—by human sociobiology and its need for the specification of relevant proximate factors at work in interaction with ultimate ones

In a related key we should add that modern evolutionary biology has made a strong and creative connection between optimization theory and natural selection but to our knowledge it has not specified rigorously the exact nature of that connection Consider for example, the possibility hesitantly suggested above that the mechanism of natural selection results in populations of individuals who feature hereditary variations in reproductive propensity Such a possibility would suggest that the current statement of the optimization principle would profit from a better fit with the workings and logic of natural selection

In conclusion, at least two more comments are necessary First, we hope to have made a plausible case in favor of the hypothesis of a two-child reproductive evolution, but we must also consider the possibility that our data represent in fact a temporary depression in the historical rhythm of human reproduction

Second, our fertility data are strongly suggestive, but, despite our effort to control for kin selection they are not adequate to demonstrate, strictly speaking that decreased fertility is associated with decreased fitness A more rigorous test would require richer data, including an analysis of multigenerational outcomes

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