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Factors Affecting the Number of Children in Five Developed Countries: A Statistical Analysis with an Evolutionary Perspective

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Evolutionary studies of reproductive fitness will lead to a deep understanding of the evolution of human behavior. However, empirical studies that include Japanese data are rare. We analyze statistical data that include subjects in five developed countries (Japan, South Korea, United States, France and Sweden). Distributions of the actual and desired numbers of children of people aged 45 or older peak at two in all countries. Our analysis shows that the unique factor that affects the actual number of children is the age of first marriage (in Japan and U.S.) or household income (in France). Other factors, such as education level, hardly affect the actual number or presence of children. We suggest directions of future studies from these results.

Keywords
developed country, fertility, fitness, number of children, statistical data

Introduction

Most animal behaviors are the product of adaptive evolution to maximize their (inclusive) fitness (Dawkins, 1976; Hamilton, 1964). The concept of fitness maximization is a central principle in evolutionary biology, especially in behavioral ecology. It is however unclear if humans also do maximize their fitness. Human behavior and psychology are very much affected by their cultural and social environments (Chagnon & Irons, 1979). Therefore, it is not straightforward to apply evolutionary perspectives to human behavior.

Since fertility is the most direct contributor to one's fitness (Kaplan & Lancaster, 2003), its decline (low fertility rate) that occurs in many countries today is a very interesting phenomenon in considering the evolution of human behavior. A large number of demographical, sociological and economic studies have been performed.

However, the number of examples of evolutionary studies on fertility decline is limited (e.g., Kaplan, Lancaster, Johnson, & Bock, 1995; Kaptijin, Thomese, van Tilburg, Liefbroer, & Deeg, 2010; Park, Cho, & Choi, 2010). Kaplan and Lancaster (2000, 2003) showed that people in modern societies in the developed world did not maximize their fitness through their fertility decisions. Borgerhoff Mulder (1998) proposed several hypotheses to explain a low fertility rate.

In this study, we analyze an international survey on low birth rates that was conducted by the Japanese government in 2010. The subject countries of this survey are five developed ones (Japan, South Korea, United States, France and Sweden). To our knowledge, almost all evolutionary studies of human fertility have been conducted in Europe and the U.S. Since our data include two Asian countries, our analysis can reveal effects of different cultural and social environments on human behavior and psychology.

In this paper, we first describe the distributions of the number of children and then try to identify factors that affect the number of children in each country. In other words, we search for factors that affect one's fitness. In behavioral ecology, it is well known that the amount of resources is a critical factor affecting one's fitness. A study of hunter-gatherer society in Kipsigis in Kenya showed that acreage, wealth in this community, was associated with the production of surviving offspring and grandoffspring (Borgerhoff Mulder, 2000). Regarding a study of pre-industrial society, Rodríguez (2007) reanalyzed a fertility survey in Fiji (Little, 1978) and showed that higher education level was associated with a smaller number of children, net of marital duration and place of residence. One of our main interests from an evolutionary perspective is whether the amount of resources (presumably represented by income or education level, for example) affects the number of children in modern developed countries.

To our knowledge, some previous reports that analyzed survey data have the following two issues for the purpose of evolutionary analysis. Firstly,

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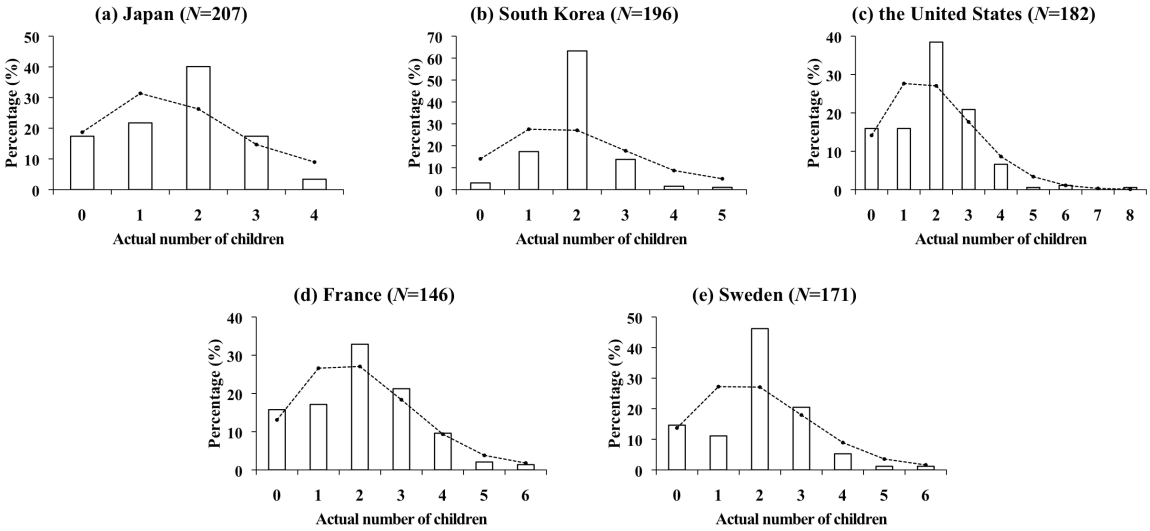

Figure 1. Distributions of the actual number of children of people aged 45 or older. The dotted lines show Poisson distributions of the same mean.

they analyzed samples that have not necessarily completed their reproduction, and therefore lifetime reproductive success was not correctly measured. Secondly, those analyses were not synthetic, only to make a summary table for each question item. In contrast, here we synthetically analyze samples with the Generalized Linear Model (GLM), paying particular attention to those who are aged 45 or older, who, we assume, have completed their reproduction.

Methods

We used International Opinion Survey on a Low Birthrate Society that was carried out by Director General for Policies on Cohesive Society, Cabinet Office of Japan in 2010. In this survey, the subjects were questioned about marriage, family, childbirth, childcare, social support and living (job, budget, and so on). Subjects are Japanese (N = 1,248), South Koreans (N = 1,005), Americans (N = 1,000), French (N = 1,002) and Swedish (N = 1,001). Samples included both sexes and their ages were from 20 to 49 years old.

For statistics, we employed the GLM to identify factors that affected the number of children. We used the actual number of children or simply the presence of children as the dependent variables. The independent variables were the age of first marriage, annual household income before taxes, the highest education level, one's creed on whether one ought to have a child after marriage, satisfaction with one's life in general and one's view of how long one should economically support children (see also Appendix for details). Error distributions were supposed to be Poisson (when the dependent variable was the actual number of children) or binomial (when it was the presence of children) in the GLM. We excluded Non-Available (NA) data from the analysis. We used the software, R version 2.13.0 (R Development Core Team, 2011).

Results

Following Kaplan et al. (1995), we assume that people aged 45 or older have completed their reproduction. We show the actual number of children of those samples in Figure 1. Except France, the distributions are significantly different from Poisson distribution (chi-square goodness-of-fit test; Japan: $\chi^2(3) = 29.6$, $p < .001$; South Korea: $\chi^2(4) = 139$, $p < .001$; U.S.: $\chi^2(5) = 24.5$, $p < .001$; France: $\chi^2(5) = 9.54$, $p = .0895$; Sweden: $\chi^2(5) = 45.6$, $p < .001$). Distributions peak at two children in all countries.

Next, we show the desired number of children in each country in Table 1. We employ the age division of three categories here (≥ 45 yrs old, 30 – 44 or 20 – 29). The peaks of the distributions are at two children in all countries and in all age categories.

To identify factors that affect the number of children, we use a backward elimination method in the GLM and select the most suitable model according to the Akaike's Information Criterion (AIC). In Japan, when the dependent variable is the actual number of children of people aged 45 or older, AIC is the smallest in the model where the independent variable is only the age of first marriage. Therefore, the model with this factor is the most appropriate. We present the regression coefficients in this most suitable model in Table 2. The positive regression coefficient for the age of first marriage indicates that the earlier one gets married, the more number of children one actually has ($z = -2.61$, $p < .01$). Table 2 also shows the value of residual deviance divided by degrees of freedom. It is much smaller than one, suggesting that there is a tendency of underdispersion of the actual number or presence of children. The other four countries are studied in a similar manner.

Table 1. Distributions of the Desired Number of Children

Country	Age group (yrs old)	Desired number of children (%)							
		0	1	**2**	3	4	5	6	≥ 7
Japan	20-29 (*N*=255)	2.35	7.45	**58.4**	29.4	0.784	1.57	0.00	0.00
	30-44 (*N*=772)	3.63	7.90	**51.7**	32.9	2.85	0.907	0.130	0.00
	≥ 45 (*N*=209)	2.87	9.09	**47.4**	36.4	3.83	0.00	0.00	0.478
South Korea	20-29 (*N*=298)	1.01	17.4	**58.7**	19.5	2.68	0.336	0.00	0.336
	30-44 (*N*=510)	1.96	13.1	**58.8**	21.2	4.31	0.392	0.00	0.196
	≥ 45 (*N*=196)	0.00	8.67	**52.0**	27.0	5.61	6.63	0.00	0.00
the United States	20-29 (*N*=308)	7.14	17.2	**42.2**	22.7	6.82	2.60	0.974	0.325
	30-44 (*N*=498)	8.84	12.2	**37.3**	26.3	8.63	2.61	1.81	2.21
	≥ 45 (*N*=182)	8.24	13.2	**42.9**	23.6	7.69	2.20	1.10	1.10
France	20-29 (*N*=295)	2.03	6.44	**56.6**	25.8	5.76	1.69	0.339	1.36
	30-44 (*N*=535)	3.18	8.97	**47.7**	27.1	7.10	4.30	1.12	0.561
	≥ 45 (*N*=145)	7.59	12.4	**35.9**	28.3	11.7	2.76	1.38	0.00
Sweden	20-29 (*N*=316)	7.28	4.11	**44.9**	30.1	8.86	2.85	0.316	1.58
	30-44 (*N*=512)	3.71	8.79	**53.1**	27.3	4.49	1.76	0.391	0.391
	≥ 45 (*N*=171)	6.43	10.5	**49.7**	24.0	7.02	1.17	1.17	0.00

Discussion

The peaks of the distributions of the actual and desired numbers of children were at two (Figure 1 and Table 1). In Japan, the Japanese national fertility surveys have repeatedly pointed out such a feature (e.g., National Institute of Population and Social Security Research, 2007). It is particularly interesting that similar tendencies are observed in all countries that are studied. This finding may suggest the presence of a factor that makes having two children optimal in modern developed countries. A concept that human individuals have an innate predisposition to optimize their reproductive strategy does not mean maximization of the number of children. The increase in cost of childcare may prevent them from having a large number of children. On the other hand, having one child is accompanied by danger of leaving no offspring. As a consequence of cost-benefit balance, having two children might be optimal (see also Borgerhoff Mulder, 1998, for alternative discussion).

Our analysis showed that the unique factor that significantly affected the actual number of children was the age of first marriage (in Japan and U.S.) or household income (in France; Table 2). In Europe, it has been argued that the decline in the number of children is caused in large part by the rise of age at first marriage and childbirth (e.g., Council of Europe, 1995; see also later reports). As to the effect of the first marriage age in Japan and U.S., two interpretations of this result are possible. One is that high consciousness of early marriage contributes to having more children. The other is that long marriage duration simply leads to a larger number of children. However, the importance of the latter explanation is marginal because couples prefer having two children in our data; late marriage may prevent them from having many, say five, children but not necessarily from having two.

With regard to the underdispersion of the actual number of children (Table 2), this result can be accounted for by a negative feedback of the number of existing children on raising another one; couples with a small number of children may try to have more children, while those with a large number of children may refrain from further reproduction (see also McCullagh & Nelder, 1989; Winkelmann & Zimmermann, 1995).

In previous studies (Kaplan & Lancaster, 2000, 2003), one of the evidences that people in modern societies in the developed world do not maximize their fitness is a negative or null correlation between resources or power, such as income or education level, and their reproductive success. Our study also showed that income did not significantly affect the actual number or presence of children (Table 2; except France). However, it might be wrong to simply regard income or education level as a representative measure of one's resources or power in modern societies. For example, even people with a low income can receive various kinds of social supports for childbirth and childcare in developed countries. Human supports, not necessarily financial ones, from their relatives also help parents foster their children well. Therefore, it is necessary to review the relationship between income and environments of childcare. Researches on cooperative breeding in non-human animals (Riedman, 1982) can help us more deeply understand human reproductive behavior (Mace & Sear, 2005).

Possible limitations of this study include the small number of subject countries (only five developed countries) and a lack of cross-sectional data over time. In addition, subjects might have answered not past situations but present ones in our survey. Hence, we cannot necessarily tell their life conditions at the moment of their reproductive decisions from the survey data. To solve this problem, it is necessary to trace the data of the

Table 2. Factors That Affect the Actual Number or Presence of Children in Those Who Are Aged 45 or Older

Dependent variables:	Actual number of children					Presence of children			
	Estimate	*S.E.*	*z*	*P*		Estimate	*S.E.*	*z*	*P*
Japan (*N*=152)									
first marriage age	**-0.0365**	**0.0140**	**-2.61**	**<0.01**	**first marriage age**	**-0.190**	**0.0670**	**-2.84**	**<0.01**
					household income	-0.441	0.257	-1.71	0.0866
					ought to have a child	**-0.659**	**0.335**	**-1.97**	**<0.05**
					economically support	0.929	0.483	1.92	0.0543
residual deviance / degrees of freedom = 0.529					residual deviance / degrees of freedom = 0.415				
South Korea (*N*=185)									
null model is the most suitable					null model is the most suitable				
residual deviance / degrees of freedom = 0.245					residual deviance / degrees of freedom = 0.0676				
the United States (*N*=126)									
first marriage age	**-0.0310**	**0.0116**	**-2.68**	**<0.01**	**first marriage age**	**-0.111**	**0.0432**	**-2.56**	**<0.05**
					education level	0.516	0.384	1.34	0.179
residual deviance / degrees of freedom = 0.700					residual deviance / degrees of freedom = 0.547				
France (*N*=95)									
household income	**0.104**	**0.0366**	**2.86**	**<0.01**	household income	0.565	0.329	1.72	0.0852
					economically support	1.13	0.604	1.87	0.0610
residual deviance / degrees of freedom = 0.601					residual deviance / degrees of freedom = 0.328				
Sweden (*N*=94)									
null model is the most suitable					null model is the most suitable				
residual deviance / degrees of freedom = 0.462					residual deviance / degrees of freedom = 0.286				

Note. The model with these factors achieved the smallest AIC. Also refer to the main text.

same person for a long period.

We cannot judge whether human behavior is adaptive or maladaptive from this single study. Rather, we believe that it serves as a prompt report. We hope that our preliminary results on human fertility will stimulate further in-depth studies.

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Appendix

Units or Scales of the Dependent/Independent Variables (Examples for Japan)

The actual number of children (unit: person)
The presence of children (0: absence or 1: presence)
The age of first marriage (unit: yrs old)
Annual household income before taxes
(unit: yen; 1: no income, 2: < 1 million (M), 3: 1 – 2 M, 4: 2 – 3 M, 5: 3 – 4 M, 6: 4 – 5 M, 7: 5 – 7 M, 8: 7 – 10 M, 9: 10 – 15 M or 10: ≥ 15 M)
The highest education level
(1: junior high school, 2: high school, 3: vocational school, 4: junior college, 5: university or 6: graduate school)
One's creed on whether one ought to have a child after married
(1: agree, 2: somewhat agree, 3: somewhat disagree or 4: disagree)
Satisfaction with one's life in general
(1: satisfied, 2: somewhat satisfied, 3: somewhat dissatisfied or 4: dissatisfied)
One's view of how long one should economically support children
(1: until completing compulsory education, 2: until high school, 3: until university, 4: until they get a job even if it is after completing school, 5: until marriage or 6: as long as possible even after marriage)