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Evolutionary approaches to fertility decline in humans: case studies in Japan

進化から見たヒトの少子化：日本を対象として

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Summary

Fertility directly affects one's reproductive fitness, so its decline (i.e., fertility decline, one of the main features of demographic transition) in modern societies is one of the most paradoxical phenomena in the evolution of human behavior. In my PhD thesis, I focus on the fertility decline in modern Japan (except a theoretical study in Chapter 5) and study various topics that are strongly related to fertility decline: the effect of socioeconomic status on the number of children and on the probability of childbirth, the effect of kin on fertility, a cultural norm for the preference for the number of children, sexual conflict between mother and father over reproductive decision-making within a couple, and the effect of peer competition and self-enhancement (i.e., options other than reproduction) on fertility decline. I conduct these studies by taking several approaches: statistical analysis of survey data, questionnaire survey at childcare facility to parents, and mathematical modeling.

Chapter 1 is General Introduction. I briefly review evolutionary approaches to fertility decline in humans. 18 years ago, Borgerhoff Mulder (1998) proposed various evolutionary hypotheses to explain low fertility rates. However, there has not been a unified consensus yet on why fertility decline occurs. In this chapter, I also summarize fertility trends in Japan. The fertility rate in Japan dramatically dropped after the World War II and it has been kept at a low level despite the economic growth and high resource availability. In addition, I explain the significance of analyzing Japanese data.

In Chapter 2, I study factors affecting the number of children. It is generally recognized that a notable feature of fertility decline is a non-positive relationship between one's socioeconomic status and the number of children. In this chapter, first, I review the existing literature

that examined the relationship between them. Some studies reported positive relationships in men and negative ones in women. However, it is also reported that the positive relationship in men was often weakened when childless individuals were excluded from the analyses. It is because childless men tend to be at lower socioeconomic status and unmarried. I found that there was much variation in the effects of one's socioeconomic status on the number of offspring. Second, I analyze Japanese cross-sectional data in 2010 and studied how household income and education level, which are measures of one's socioeconomic status, affect the number of children. My conclusion is that when the effect of the age at first marriage was statistically controlled, socioeconomic status did not have significantly positive effects on the number of children. In the analyses, I found no sex-specific effects of one's socioeconomic status.

In Chapter 3, I study factors affecting the probability of childbirth. In order to reveal the conditions that could facilitate childbirth, it is necessary to analyze not only cross-sectional surveys but also panel data that track the same person for a long period. In this study, I explore factors that influence the probability of childbirth. I analyze Japanese panel data by a statistical method called Cox proportional hazard model. Subjects of my analysis are married women and their childbirth records from 2004 to 2009. Contrary to the predictions based on the theory of behavioral ecology, I found no positive relationships between good parental conditions for childcare, such as high income, increase in income, or co-residence with parents (i.e., grandparents of children), and the occurrence of childbirth. I also found that the number of existing children had a significant impact on the probability of childbirth. The likelihood of further childbirth by couples with one child was nearly equal to that of childless ones. However, the corresponding likelihood of couples with two children was about five times lower than that of

childless ones. The total fertility rates in modern developed societies are quite low and couples prefer having two children. This trend is known as the two-child norm, but it is a paradoxical phenomenon in terms of fitness maximization. My result provides new quantitative evidence of this norm.

In Chapter 4, I apply the perspective of sexual conflict between mother and father (her husband) to the fertility decline. It is predicted that, under serial monogamy that allows mate changes, the ideal number of children for women should be smaller than that for men, because the cost of reproduction for women should be higher than that for men. My reasoning is that if the cost of child-bearing and child-caring is higher in women than men, and if women, who want a smaller number of children than their husbands, have gained more power in reproductive decision-making within a couple owing to the modernization of the society, fertility decline should occur. Until now, few evolutionary studies have analyzed empirical data in modern developed societies with such a perspective. My questionnaire survey in an urban area in Japan revealed that mothers actually experienced greater cost during childcare than fathers. However, in contrast to my prediction, I found no sex differences in the ideal number of children within a couple in many cases. About 60% of parents wanted two children when they were childless. Moreover, my analysis showed that mothers and their husbands had equal power in their decision-making to bear children. My results suggest that men may not enjoy the advantage of serial monogamy in modern developed societies.

In Chapter 5, I study the effect of peer competition and self-enhancement on fertility decline. To understand fertility decline, it is necessary to explain how parents allocate their wealth to offspring/themselves and what environmental conditions lead to a decrease in fertility. In this study, I analyze a wealth-fertility

relationship from the perspectives of peer competition among offspring and self-enhancement. In urban societies with competitive labor and mating markets, parental cost for childcare should be larger and fertility should consequently be lower than that in rural societies. Some examples of self-enhancement are dressing in designer clothing, acquiring luxury cars, and enjoying leisure activities. These may be extreme examples, but it is reasonable to assume that, in modern life styles, people face attractive options that do not directly enhance their reproductive success. I assume that parents try to maximize *"Happiness"*, which is defined as the combination of biological fitness and self-enhancement. Note that this assumption is deviated from a purely evolutionary model. My mathematical models predict that high levels of investment in child quality and self-enhancement reduce fertility. These results would match the situations observed in modern low-fertility societies.

Chapter 6 is General Discussion. As I described above, I have obtained a number of results on fertility decline by taking a variety of approaches. I believe that I have contributed to providing a novel framework and pieces of evidence that are related to fertility decline. Based on these results, I discuss the relationship between socioeconomic success and reproductive success. It is expected that parents in modern developed societies keep high socioeconomic status in order to provide much parental investment for their children. It is because, in a competitive environment, lower-quality offspring tend to lose in peer competition in labor and mating markets, and to result in lower reproductive success. In such an environment, parents should set a high value on parental investment and would aim to produce a small number of high-quality children. I also discuss effects of various kinds of sexual conflict on fertility decline. There are various measures other than family size to study sexual conflict between parents. I provide new ideas of studies on sexual conflict over contraception and induced abortion.

Additionally, I argue the relationship between evolutionary biology and social sciences. I believe that evolutionary thinking gives us a concise and rigid theoretical framework to study human behavior based on fitness maximization, which enables us to consider “why” questions (i.e., ultimate factors). Lastly, I give a perspective towards an integrated understanding of fertility decline and other evolutionarily (mal)adaptive behaviors in humans.

List of publications

Peer-reviewed papers

[4] Morita, M., Ohtsuki, H., & Hiraiwa-Hasegawa, M. (accepted). "Does sexual conflict between mother and father lead to fertility decline? A questionnaire survey in a modern developed society" *Human Nature*.

[3] Morita, M., Ohtsuki, H., & Hiraiwa-Hasegawa, M. (in press). "A panel data analysis of the probability of childbirth in a Japanese sample: new evidence of the two-child norm" *American Journal of Human Biology*. http://dx.doi.org/10.1002/ajhb.22776

[2] Morita, M., Ohtsuki, H., Sasaki, A., & Hiraiwa-Hasegawa, M. (2012). "Factors affecting the number of children in five developed countries: a statistical analysis with an evolutionary perspective" *Letters on Evolutionary Behavioral Science*, 3(1): 7-11. http://dx.doi.org/10.5178/lebs.2012.19

[1] Morita, M. (2011). "Sex differences in human greeting behaviors in waiting and meeting situations: a field study in Japan" *Journal of Human Ergology*, 40(1-2): 79-83. http://dx.doi.org/10.11183/jhe.40.79 [The contents of this paper are not included in my PhD thesis.]

Chapter 1

General Introduction

1.1. Evolutionary approaches to fertility decline in humans

From the perspective of behavioral ecology (i.e., fitness maximization), there are many remarkable, seemingly paradoxical, phenomena in human behavior. To list a few, fertility decline (e.g., Borgerhoff Mulder, 1998; Mace, 2014), child abuse (e.g., Daly and Wilson, 1985, 2008), menopause (e.g., Hawkes and Coxworth, 2013; Hawkes et al., 1998), and suicide (Aubin et al., 2013; deCatanzaro, 1980) are typical examples that can lead to a decrease in one's reproductive fitness. Fertility decline means a decrease in the number of children despite affluent resource availability in modern environments. Child abuse has harmful effects on child survival. Menopause means the cessation of reproduction while women are still alive. Suicide terminates life and abandons future reproduction voluntarily.

Among the above-mentioned phenomena, I especially pay attention to fertility decline. In Europe, for example, fertility radically declined in the early 20th century (e.g., Borgerhoff Mulder, 1998). Nowadays, except for some African countries, low fertility is a worldwide phenomenon (see also for Lee, 2003 for a review). In this chapter, I overview the framework of evolutionary approaches to fertility decline. Fertility directly affects one's reproductive fitness, such as the number of offspring (Kaplan and Lancaster, 2003), so its decline and the following low birthrate state are one of the most paradoxical phenomena in the evolution of human behavior (e.g., Barkow and Burley, 1980; Borgerhoff Mulder, 1998; Kaplan and Lancaster, 2000, 2003; Lawson and Mace, 2011; Mace, 2014; Vining, 1986, note that Lawson, D. W., Sear, R., Shenk, M., Stearns, S. and Kaplan, H. are editing a forthcoming

special issue in *Phil Trans R Soc B*; this would review human fertility from evolutionary perspectives).

The emergence of modern birth control method is often regarded as one of the triggers of fertility decline (see also Alvergne et al., 2013; Colleran and Mace, 2015), but some counterarguments, for example, that fertility decline has started before the invention of contraceptives, also exist (e.g., Borgerhoff Mulder, 1998, see also Chapter 6). In a previous study, Borgerhoff Mulder (1998) proposed three evolutionary hypotheses to explain a low fertility rate: that (1) it is adaptive in a competitive environment through a peer competition among offspring and a trade-off between offspring quality and quantity, that (2) it is maladaptive and led by non-genetic cultural transmission, such as the imitation of socially successful, but not necessarily reproductively successful, other individuals, and/or that (3) it is a maladaptive by-product of a mismatch between the evolved psychological mechanisms in humans and the current environment that has rapidly changed from the ancestral one (see also Chapter 6).

Although some studies have been conducted based on these ideas until now (e.g., Alvergne et al., 2013; Colleran et al., 2014; Goodman et al., 2012; Hill and Reeve, 2005; Ihara, 2008; Ihara and Feldman, 2004; Shenk, 2009; Shenk et al., 2013; Snopkowski and Kaplan, 2014, see also Alvergne and Lummaa, 2014; Sear, 2015), there has not been a unified consensus yet on why fertility decline occurs. As for the hypothesis (1), several studies showed that a smaller number of children did not increase one's number of grandchildren or long-term reproductive fitness (e.g., Goodman et al., 2012; Kaplan et al., 1995, see also Jones and Bird, 2014). These pieces of evidence mean that the effect of peer competition among offspring and the effect of trade-off between offspring quality and quantity on fertility decline are not so strong (see also Chapter 5). With regard to the hypothesis (2) (see also Boyd and Richerson, 1985;

Richerson and Boyd, 2005 for details), it has not been revealed yet why such culture arose and why people adjust their behavior to the culture. Although researchers showed some processes of cultural transmission that lead to fertility decline, its ultimate factor has not been directly explored. Regarding the hypothesis (3), this idea can be a breakthrough in considering the evolution of modern human behavior. However, to my knowledge, we have not detected which psychological mechanism led to the fertility decline in a modern society and what environmental change was crucial.

Borgerhoff Mulder's review was published 18 years ago, but we have not achieved a clear and robust answer yet to "why fertility decline occurs". In my PhD thesis, I study various topics that are strongly related to fertility decline: the effects of socioeconomic status on the number of children (Chapter 2) and on the probability of childbirth (Chapter 3), the effect of kin on the probability of childbirth (Chapter 3), a social or cultural norm for the preference for having two children (Chapter 3), sexual conflict between mother and father over reproductive decision-making within a couple (Chapter 4), and the effect of peer competition among offspring and the effect of self-enhancement (i.e., attractive options other than reproduction) on fertility decline (Chapter 5). I conduct these studies by taking several approaches: statistical analysis of survey data, questionnaire survey at childcare facility, and mathematical modeling. Some of the topics have not been quantitatively or empirically analyzed in previous studies, so I believe that my PhD study provides novel insights on the fertility decline. For reviews of previous studies on these topics, see the Introduction sections of each chapter.

Note that, in demography, the term "fertility decline" is defined as "a state where birthrates have been kept below than the replacement-level fertility continuously" (Jinko-gaku Kenkyukai, 2009)

or “that where the total fertility rate decreases five percent lower than its peak value” (Bryant, 2007). On the other hand, in my studies, I use the term more broadly to mean “a low-birthrate state compared with when everyone maximizes one’s reproductive fitness”.

1.2. Fertility trends in Japan and the significance of analyzing Japanese data

I study the fertility decline in Japan (except in the theoretical study in Chapter 5). I show fertility trends in Japan in Figure 1.1 (the data are derived from National Institute of Population and Social Security Research, 2015). The fertility rate in Japan dramatically dropped after the World War II and it has been kept at a low level despite the economic growth and high resource availability. The total fertility rate was 4.54 in 1947, 3.65 in 1950, 2.00 in 1960, 2.13 in 1970, 1.75 in 1980, 1.54 in 1990, 1.36 in 2000, 1.39 in 2010, and 1.42 in 2014 (see Chapter 4 for an explanation for such a transition). In my PhD thesis, I mainly focus on the recent low-fertility state since 2003.

There are often evolutionary bases in human behavior, but their cultural and social environments also have strong effects on it. Therefore, cross-cultural studies are necessary (e.g., Sear, 2016). However, most of the evolutionary studies on fertility decline were based on the data in Europe and the USA and there exist fewer studies that analyzed Asian data, including that of Japan (see Chapter 2 for details). I study Japanese data, so I believe that my study will contribute to revealing effects of different cultural and social environments on human fertility.

Figure legends

Figure 1.1. Fertility trends in Japan from 1947 to 2014.

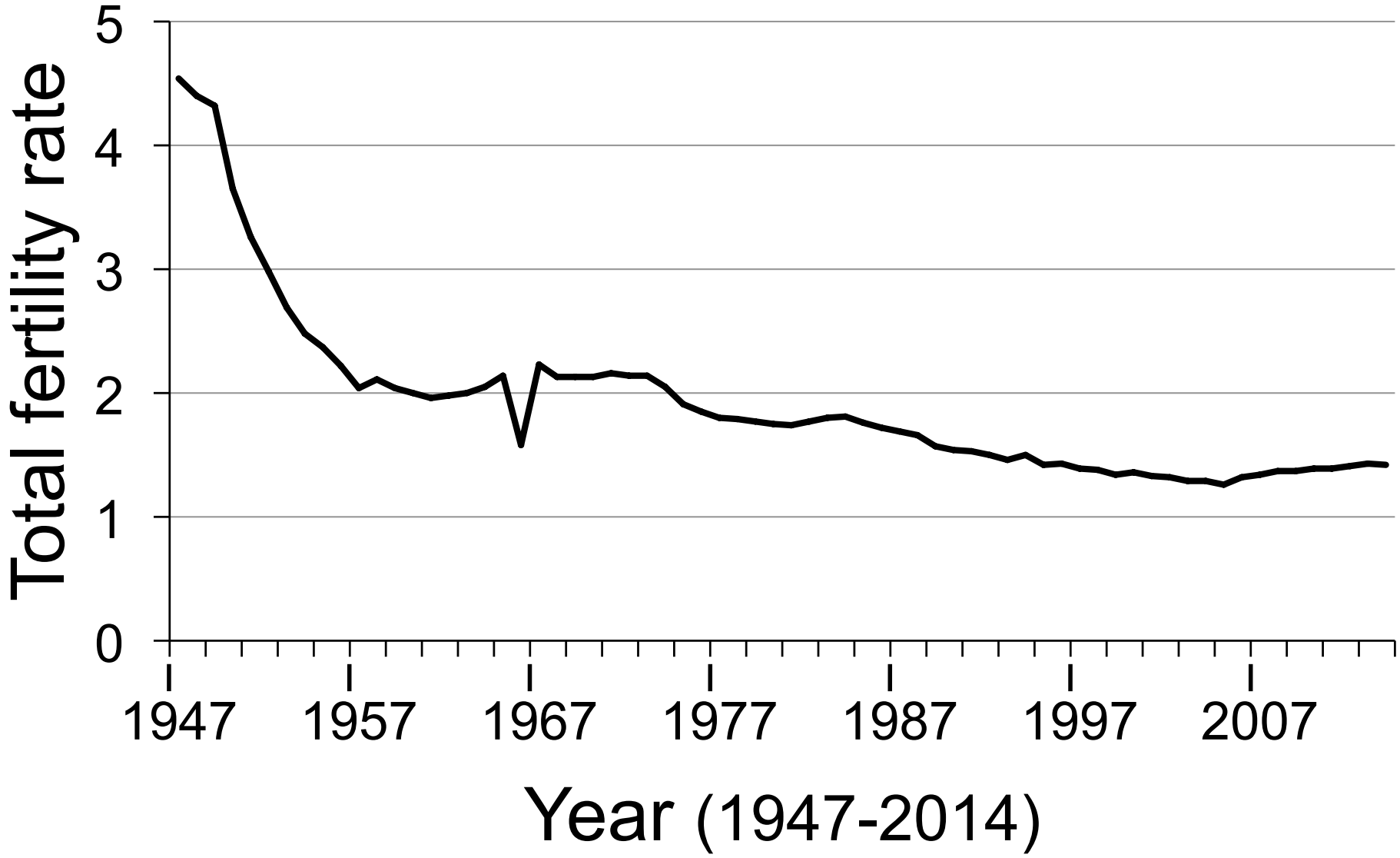

Fig. 1.1 Fertility trends in Japan from 1947 to 2014

Chapter 2

General title

Factors affecting the number of children: a statistical analysis of cross-sectional data

More specific title

Effects of socioeconomic status on the number of children in modern Japan: a statistical analysis with an evolutionary perspective

This chapter is an improved version of Morita et al. (2012) published in Letters on Evolutionary Behavioral Science. I have incorporated new analyses, introduction, and discussion.

2.1. Abstract

It is well recognized that there generally exists a non-positive relationship between one's socioeconomic status and the number of offspring in modern low-fertility societies. In this chapter, first, I review the existing literature that examined the relationship between them. Some studies reported positive relationships in men and negative ones in women. However, it is also reported that the positive relationship in men was often weakened when childless individuals were excluded from the analyses. It is because childless men tend to be at lower socioeconomic status and unmarried. I found that there was much variation in the effects of one's socioeconomic status on the number of offspring. Second, I analyze Japanese cross-sectional data and study how household income and education level, which are measures of one's socioeconomic status, affect the number of children. My conclusion is that when the effect of the age at first marriage was statistically controlled, socioeconomic

status did not significantly have positive effects on the number of children. In the analyses, I found no sex-specific effects of socioeconomic status, either. I also discuss a methodological limitation of analyzing cross-sectional data to study factors affecting the lifetime number of children.

2.2. Introduction

2.2.1. Relationship between socioeconomic status and the number of offspring

Until now, numerous studies have argued whether fertility decline in humans is evolutionarily adaptive or not, and if not, why such maladaptive behavior arose. One way to see whether one's behavior (and decision-making) regarding fertility is adaptive or maladaptive is to analyze its reproductive fitness consequences, such as the number of offspring. If a factor (e.g., the amount of resources or social status) increases/decreases one's reproductive fitness, behavior that seeks the factor would be concluded to be adaptive/maladaptive. I believe that exploring factors that affect one's number of offspring is a rational first step to understand evolutionary implications of fertility decline.

A notable and remarkable feature of fertility decline is a negative or null relationship between socioeconomic status, such as income or education level, and the number of offspring. It has been reported that higher-status individuals do not tend to have a larger number of children than lower-status ones (e.g., Borgerhoff Mulder, 1998; Hill and Reeve, 2005; Kaplan and Lancaster, 2000, 2003; Vining, 1986). Vining (1986) concluded that such a negative or null relationship between socioeconomic success and reproductive success is a great challenge to evolutionary approaches to human behavior (see also Alvergne and Lummaa, 2014; Vining, 2011 for recent discussions). In this chapter, I first review the existing literature that examined the relationship

between socioeconomic status and the number of offspring. While there were some reviews in the past (e.g., Barrett et al., 2002; Low, 2000), few extensive reviews that discussed recent findings have been conducted. I will describe a number of new studies that must be important for a better understanding of the effects of socioeconomic success on one's reproductive success (note that Stulp, G. and Barrett, L., personal communication, conduct a literature survey and discuss the wealth-fertility relationship widely).

In general, theories of behavioral ecology predict that the amount of resources and socioeconomic status are critical factors for one's reproductive success and hence that there should be a positive relationship between them. Researchers apply this prediction to human societies and study the relationship by analyzing statistical data (e.g., Barthold et al., 2012; Hopcroft, 2006, 2015, see also Ellis, 1995). In traditional and pre-industrial societies (e.g., hunter gatherer, pastoralist, horticulturalist, and historical societies), there is a positive relationship between one's socioeconomic status and reproductive success, especially in men (reviewed in Betzig, 1986; Fieder and Huber, 2012; Hopcroft, 2006; Pérusse, 1983). In these societies, examples of status measures are hunting ability, the number of livestock, land ownership, and power. Borgerhoff Mulder (2000) showed that individuals who had a larger land had a larger number of children and grandchildren in semi-nomadic herders of Kenya (Kipsigis). Betzig (1986) showed that leader men in some despotic societies had more than a hundred wives and had numerous marital relationships with them simultaneously.

In previous studies of modern but developing societies, however, a negative relationship appears (e.g., Bangladesh: Shenk et al., 2013; Bolivia: Snopkowski and Kaplan, 2014; India: Shenk, 2009). In such studies in modern societies, income and education level are often used as measures of one's socioeconomic status (e.g., Barthold et al., 2012;

Hopcroft, 2006, 2015). Additionally, some studies revealed that the relationship between socioeconomic status and fertility shifted from a positive one to a null or negative one during the demographic change from a high- to low-fertility society (e.g., Finland: Liu and Lummaa, 2014; Mongolia: Alvergne and Lummaa, 2014). Skirbekk (2008) reviewed the temporal change of this relationship via macro analyses of 129 resources and confirmed such a shift. These pieces of evidence suggest that lifestyles and socioeconomic conditions in modern societies very much differ from those in traditional and pre-industrial ones. Next, I review previous studies on the relationship between one's socioeconomic status and the number of offspring in modern developed societies.

2.2.2. A summary of the effects of socioeconomic status on the number of offspring in modern developed societies

In Table 2.1, I summarize factors that are reported to affect the number of offspring in modern developed societies in previous literature. Though there are some measures of reproductive success (e.g., mating success, child survival, or probability of having children), here I limit my survey to literature that studied the number of offspring as a measure of reproductive success.

Many studies reported notable sex differences in the relationship between socioeconomic status and the number of offspring (see Hopcroft, 2015 for a brief summary). It is well known that men with higher socioeconomic status tended to have a larger number of offspring than those with lower socioeconomic status (personal income: Barthold et al., 2012 (marginal effect); Fieder and Huber, 2007, 2012; Hopcroft, 2006, 2015; Nettle and Pollet, 2008; Weeden et al., 2006, education level: Fieder and Huber, 2007; Goodman and Koupil, 2009; Kravdal and Rindfuss, 2008, other measures: Fieder and Huber, 2012; Fieder et al.,

2005; Goodman and Koupil, 2009; Hauber, 2007). There were fewer studies that found a negative relationship for men, and most of these studies used education level as a measure of socioeconomic status (Barthold et al., 2012; Fieder and Huber, 2012; Hopcroft, 2006, 2015; Nettle and Pollet, 2008; Kaplan et al., 2002; Weeden et al. 2006). It was discussed that the negative effect of education level on the number of offspring was mainly due to the delay in one's reproduction (e.g., Kaplan et al., 2002; Weeden et al., 2006). Note that some studies reported a null relationship (see Table 1.1 for details). On the other hand, for women, most of the studies reported a negative or null relationship between their socioeconomic status and the number of offspring (Table 1.1).

Previous studies indicated that childlessness had a significant influence on the relationship between socioeconomic status and the number of offspring. In other words, whether or not including the data of childless individuals in the analysis had a large impact on the relationship. In men, childless individuals tend to be at lower socioeconomic status and unmarried. Fieder et al. (2011) showed that lower-income men in Brazil, Mexico, Panama, South Africa, USA, and Venezuela tended to be unmarried and childless. Therefore, the positive relationship between socioeconomic status and the number of offspring in men was often weakened when childless individuals were excluded from the analyses (Barthold et al., 2012; Nettle and Pollet, 2008; Fieder and Huber, 2007, 2012, see also Goodman et al, 2012; Fieder et al., 2005; Weeden et al. 2006). These results are consistent with the hypothesis that women should choose higher status men as their partner to gain more access to resources (e.g., Buss, 1989, 1999). For women, most of the literature reported a negative relationship between socioeconomic status and the number of offspring both when childless individuals were included in the analyses and when they were not. There

are three explanations of this result: (1) a trade-off between childbearing and making efforts to obtain higher education or employment (e.g., Goldstein and Kenney, 2001; Marini, 1984), (2) a trade-off between offspring quality and quantity to bear the optimum (not maximum) number of offspring (e.g., Lawson and Mace, 2011), and/or (3) a delay in reproduction as a result of preferentially searching a small number of high-status men (e.g., Wiedermann, 1993) (reviewed in Fieder and Huber, 2007). Keizer et al. (2008) indicated that pathways into childlessness were different between men and women in the Netherlands. They showed that a higher education level and a higher career led to childlessness more in women, but not in men. As I reviewed, two keywords for better understanding the effects of one's socioeconomic status on the number of offspring are "sex difference" and "childlessness".

A non-positive relationship between one's socioeconomic status and the number of offspring is recognized as a feature of fertility decline *in general*; at least, few studies showed that a higher socioeconomic status led to a larger number of offspring. However, as I reviewed above, there was much variation in the relationship. This means that it has not been clarified yet how one's socioeconomic success affects the number of children that he/she has.

2.2.3. Aim

Since few robust patterns have been found between one's socioeconomic status and the number of offspring, I believe that further investigation in many kinds of societies is necessary to understand their relationship. Cross-cultural and descriptive studies will play an important role for that purpose (see also Sear, 2016). In this respect, analyses of Japanese data are missing; there exist few studies that analyzed Japanese data from an evolutionary perspective. Based on my literature survey about the effects of socioeconomic status on the number

of offspring, I analyze Japanese cross-sectional data to explore factors affecting the number of children. In particular, I study whether there is a positive relationship between one's socioeconomic status and the number of children. In my previous paper (Morita et al., 2012) that analyzed the same data set, I did not study the sex difference in the effects of one's socioeconomic status on the number of children. In this chapter, I study the sex difference, too.

As I explained, I am interested in the effect of childlessness on the number of children. However, there are some limitations in analyzing the effect in my data set. In some previous studies, subjects of analyses included not only married but also unmarried individuals. Such a choice of subjects means that the effect of unmarried individuals on the number of children is large because childless individuals tend to be unmarried (in men). On the other hand, there are few unmarried parents in my data set, so it is expected that my data set is preferable for analyzing the data of married individuals only to study factors affecting the number of children. I assume that there exists a large gap between married and unmarried individuals about whether they have children or not (i.e., being childless or not) in Japan contra other countries, such as European ones. Additionally, in my data set, there are few married childless individuals. These two characteristics (i.e., few unmarried parents and few married-childless individuals) do not enable me to analyze the effect of childlessness appropriately in this single study. In Japan (and societies that have the two characteristics above), it is necessary to analyze factors affecting marriage and/or the age at marriage to reveal the effect of childlessness on the number of children. To sum up, in my view, because one's marital status (i.e., married or unmarried) has a strong influence on the number of children (especially whether they have children or not), it should be necessary to analyze the effect of one's socioeconomic status on his/her marriage. By doing so, I can discuss

more clearly the effect of childlessness on the relationship between socioeconomic status and the number of children. However, this is a quite large research topic, and I leave the project as another study.

2.3. Methods

2.3.1. Procedure and data

One of the typical methods to explore factors affecting the number of children is to regard the number of children of individuals older than a certain threshold age (for example, 45 years old) as their lifetime reproductive success and analyze which of their current factors affect this number (e.g., Barthold et al., 2012; Kaplan et al., 1995). I employed this approach in this study. Additionally, I also used the age-adjusted number of children (e.g., Shenk, 2009; Shenk et al., 2013) to overcome a small number of subjects older than 45 years old. The age-adjusted number of children is the estimated number of children at age 45 after statistically controlling the current age (see below). For this variable, I used the data of the number of children of all-age adults (from 20 to 49 years old in my data set). I analyzed the source data of the International Opinion Survey on a Low Birthrate Society conducted by the Director General for Policies on Cohesive Society, Cabinet Office of Japan in 2010. In this survey, subjects were chosen from all over Japan by stratified random sampling. To conduct this study, I needed no ethics permission.

2.3.2. Statistical analysis

To explore factors that affect the number of one's children, I employed generalized linear models (GLMs) with a Poisson error distribution and a log link function. Subjects of my analysis to study factors affecting the lifetime number of children were married individuals aged 45 or more (N=147). I did not use the data of subjects

with not-available (NA) data items for some variables below.

The dependent variable was the number of children (person; continuous). Independent variables were: sex (binary); household income (continuous; 10 levels, from low to high); the age at first marriage (years old; continuous) own and partner's education level (continuous; 6 levels, from low to high); and the presence of housewife (binary). I took a special care in treating the effect of income. Many previous studies used men's and/or women's personal income. However, the personal income of a woman may not reflect her socioeconomic status correctly because housewives who have no earnings are still common in Japan. Accordingly, I used household income in my analyses and incorporated the status of women's employment as another independent variable to statistically control its effect (see also the Discussion section). As a control factor, I also incorporated the age at first marriage (years old; continuous). Descriptive statistics of each variable of subjects that I analyzed were shown in Table 2.2. I analyzed interaction terms between sex and other independent variables to explore sex differences. I also calculated Pearson's r to check multiple collinearities between independent variables (see the footnote of Table 2.3).

Additionally, I also studied factors affecting the age-adjusted number of children. In this analysis, I used the data of married individuals of all ages (N=673) and included their age (years old; continuous) as one of the independent variables to control its effect statistically. I conducted these analyses of GLMs using R version 2.15.2 (R Core Team, 2012) with the *glm* function.

2.4. Results

2.4.1. Distribution of the number of children

First, I showed in Figure 2.1 the distribution of the number of

children that individuals aged 45 or more have. The distribution peaked at two and significantly differed from Poisson distribution (chi-square goodness-of-fit test, $P<0.001$, $\chi^2(3)=29.6$).

2.4.2. Factors affecting the lifetime number of children

I showed the summary of my analysis regarding factors affecting the lifetime number of children in Table 2.3a. I found no significant (i.e., $P<0.05$) interaction terms between sex and other independent variables, so I showed only the main effects there. This result indicated that no factors had a sex-specific effect on the number of children. The unique factor affecting the lifetime number of children was the age at first marriage ($P<0.01$, Table 2.3a, Figure 2.2). The negative value of its estimated coefficient indicated that the earlier one got married, the more number of children one had. Household income or education, which are measures of one's socioeconomic status, had no significant effects on the lifetime number of children (Table 2.3a, Figure 2.3, and Figure 2.4). In these analyses, I analyzed only their linear effects, but according to Figure 2.3a and Figure 2.4a, there existed no clear intermediate optima; individuals with middle socioeconomic status did not have the largest number of children compared with those with high or low status.

I also showed the values of residual deviance and degrees of freedom in the footnote of Table 2.3a. The value of residual deviance divided by degrees of freedom was much smaller than one, suggesting that there was a tendency of underdispersion of the lifetime number of children. See Figure 2.5 for the scatter plot between the actual number of children and the estimated λ-value of Poisson distribution.

2.4.3. Factors affecting the age-adjusted number of children

In the same manner, I summarized the results of factors affecting the age-adjusted number of children in Table 2.3b. I found no significant

interaction terms between sex and other independent variables. Except for the effect of age (i.e., a control effect), I found similar results as before; the unique factor that affected the number of children was the age at first marriage ($P<0.001$). The effect of household income was not significant. Sex, own education level, and the presence of housewife had marginal (but not statistically significant) effects on the number of age-adjusted children (see Table 2.3b). Education level had a marginally positive effect ($P=0.071$).

2.5. Discussion

In this chapter, I explored factors affecting the number of children and studied the effects of socioeconomic status by analyzing Japanese cross-sectional data. The unique significant factor affecting the number of children was the age at first marriage, and there was not a significantly positive relationship between one's socioeconomic status, such as income or education level, and the lifetime/age-adjusted number of children. These results match those in my previous report (Morita et al., 2012). I have provided a new piece of Japanese evidence on the effects of socioeconomic status on the number of children.

In my analyses, I did not find any sex sex-specific effects (i.e., interaction terms between sex and other variables had no significant effects) in the factors affecting the number of children (cf. Barthold et al., 2012; Nettle and Pollet, 2008; Fieder and Huber, 2007, 2012; Hopcroft, 2015). I found no sex-specific effects of income on the number of children. One possible discussion of the result is following; I used household (not personal) income, so its sex difference may be weakened. However, using household income as a measure should be reasonable in Japan, because I believe that it should reflect women's socioeconomic status more correctly than personal income. Perhaps I will need to develop the framework of my analysis to study the sex differences in the

effect of income on the number of children, because personal income may reflect more sex-specific backgrounds (but less women's socioeconomic status) than household income. In fact, I also analyzed the models that included personal income instead of household income as an independent variable. In the analyses, interaction terms of sex and personal income were not significant - but the multiple collinearity between them were large (i.e., $r>0.7$). When I incorporated personal income instead of household income and excluded sex from the original model, personal income had no significant effects. According to these results, I assume that neither household income nor personal income has significant effects on the number of children.

To sum up, my conclusion is that when the effect of the age at first marriage was statistically controlled, socioeconomic status did not have a strong effect on the number of children (Table 2.3). Although there are some methodological and theoretical limitations in my study, I have shown that there were no clear positive relationships between one's socioeconomic status and the number of children. I will discuss the non-positive relationship between socioeconomic success and reproductive success and its evolutionary implications in more detail in Chapter 6 as a part of the general discussion by referring to my results in other chapters.

It may be possible to understand the positive relationship between one's socioeconomic status and the number of offspring for men in traditional and pre-industrial societies by paying attention to the benefit of having multiple sexual partners (e.g., Lappegård and Rønsen, 2013). If a higher socioeconomic status enables men to have a larger number of sexual partners, they will have a larger number of offspring for themselves (not per partner) (see Chapter 4 for detailed explanations of the reproductive advantage for men that could enable them to gain higher multipartner fertility). This scenario leads to a positive relationship

between one's socioeconomic status and the number of children in men. However, when having multiple sexual partners is socially banned and/or ecologically restricted in modern societies, this positive relationship should disappear (see also Chapter 6). In my literature review, I did not take into account or consider the effect of socioeconomic status on multipartner fertility. This is one of my future works.

In many previous studies, income and education level were mainly used as measures of one's socioeconomic status (see also Stearns et al., 2010 for a review analyzing other factors). However, there may exist other ways to more appropriately measure one's socioeconomic status. Borgerhoff Mulder and Behaim (2011) studied what types of wealth were actually important for success in raising children for women in an African horticultural population. They found that the relational wealth (i.e., social ties) and material wealth (i.e., productive capital) were more important than embodied wealth (i.e., stocks of health, skill, and productive knowledge). Therefore, the number of offspring cannot be explained fully by a simple measure of socioeconomic status, such as income or education level (see also Shenk et al., 2013; Snopkowski and Kaplan, 2014).

A number of studies have stressed the importance of cooperative breeding, defined as a breeding system where not only parents but also other individuals take part in childcare, in human reproductive behavior (e.g., Sear and Coall, 2011; Sear and Mace, 2008; Strassmann and Garrard, 2011). Sear and Coall (2011) generally concluded that the presence of grandparents is beneficial to childcare in post-transition societies. The presence of kin has a positive effect on the number of one's children. I will consider the effect of kin on fertility in terms of cooperative breeding in the next chapter (see Chapter 3). On the other hand, Sear and Coall (2011) also discussed that kin affected fertility not only positively but also negatively. They suggested that, under the

demographic transition, unhealthy grandparents (due to a longer life) would cause fertility limitation because we must take care of the old. In modern developed societies, not only kinship but also adequate social support will make childrearing easier, so these factors should also be considered.

I found that the distribution of the number of children peaked at two (Figure 2.1). I also confirmed that such a trend was also observed in other countries, such as in South Korea, the US, France, and Sweden (data not shown, see Morita et al., 2012). This trend is known as the two-child norm. I will study the detail of this norm in the next chapter (see Chapter 3). Additionally, I showed the underdispersion of the number of children (Table 2.3, see also Figure 2.5). Barthold et al. (2012) also reported such an underdispersion when they analyzed factors affecting the number of children by using GLMs with a Poisson error distribution. 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. In future, it is necessary to construct a more complex statistical model, such as the one where the rate of bearing next offspring depends on the number of existing children, to better explain my data.

I also found that the age at first marriage had a significantly negative effect on the number of one's children (Figure 2.2). In Europe, it has been argued that the decline in the number of children is caused in large part by the rise of the age at first marriage (e.g., Council of Europe, 1995). There are two possible interpretations to understand the effect of the age at first marriage. One is that high awareness of early marriage contributes to having more children. A positive attitude towards early marriage may benefit one's fertility consequence. The other is that long marriage duration simply leads to a larger number of children. However,

the importance of the latter explanation will be marginal because couples prefer having two children in my data (Figure 2.1); late marriage may prevent them from having many, say five, children.

A methodological limitation of the previous and present studies is that subjects' current conditions are often used as candidate factors affecting the lifetime number of children. However, such a method cannot clarify their past situations, such as at their marriage, childbirth or childcare, which will be much more important for their reproductive decision-making (Barthold et al., 2012). To solve this limitation, it is necessary to study the timing of reproduction and the process of reproductive decision-making. Analyses of longitudinal data that track the same person (i.e., panel data) are ideal for that purpose. I will analyze panel data in the next chapter and explore factors that affect the probability of childbirth in a Japanese sample (see Chapter 3).

Figure legends

Figure 2.1. The distribution of the number of children of individuals aged 45 or more.
The dotted line shows the Poisson distribution of the same mean value.

Figure 2.2. The relationship between the age at first marriage and the lifetime number of children.
Each lattice point was spread for showing the sample size by using the *jitter* function in R.

Figure 2.3. The relationship between household income and the lifetime number of children.
Each lattice point was spread for showing the sample size by using the *jitter* function in R.

Figure 2.4. The relationship between own education level and the lifetime number of children.
Each lattice point was spread for showing the sample size by using the *jitter* function in R.

Figure 2.5. The relationship between the actual lifetime number of children and the estimated λ-value of Poisson distribution.

Table captions

Table 2.1. A summary of factors affecting the number of offspring in modern developed societies.

Table 2.2. Descriptive statistics of each variable of subjects.
(a) individuals aged 45 or more, and (b) all ages.

Table 2.3. A summary of factors affecting the number of children.
(a) lifetime, and (b) age-adjusted.

Data accessibility

Researchers can access the original data of the survey by obtaining the permission by the institute that conducts and manages original survey. I cannot make the raw data that I analyzed in this paper open access, because of the agreement with the institute. More information is available personally by contacting the author.

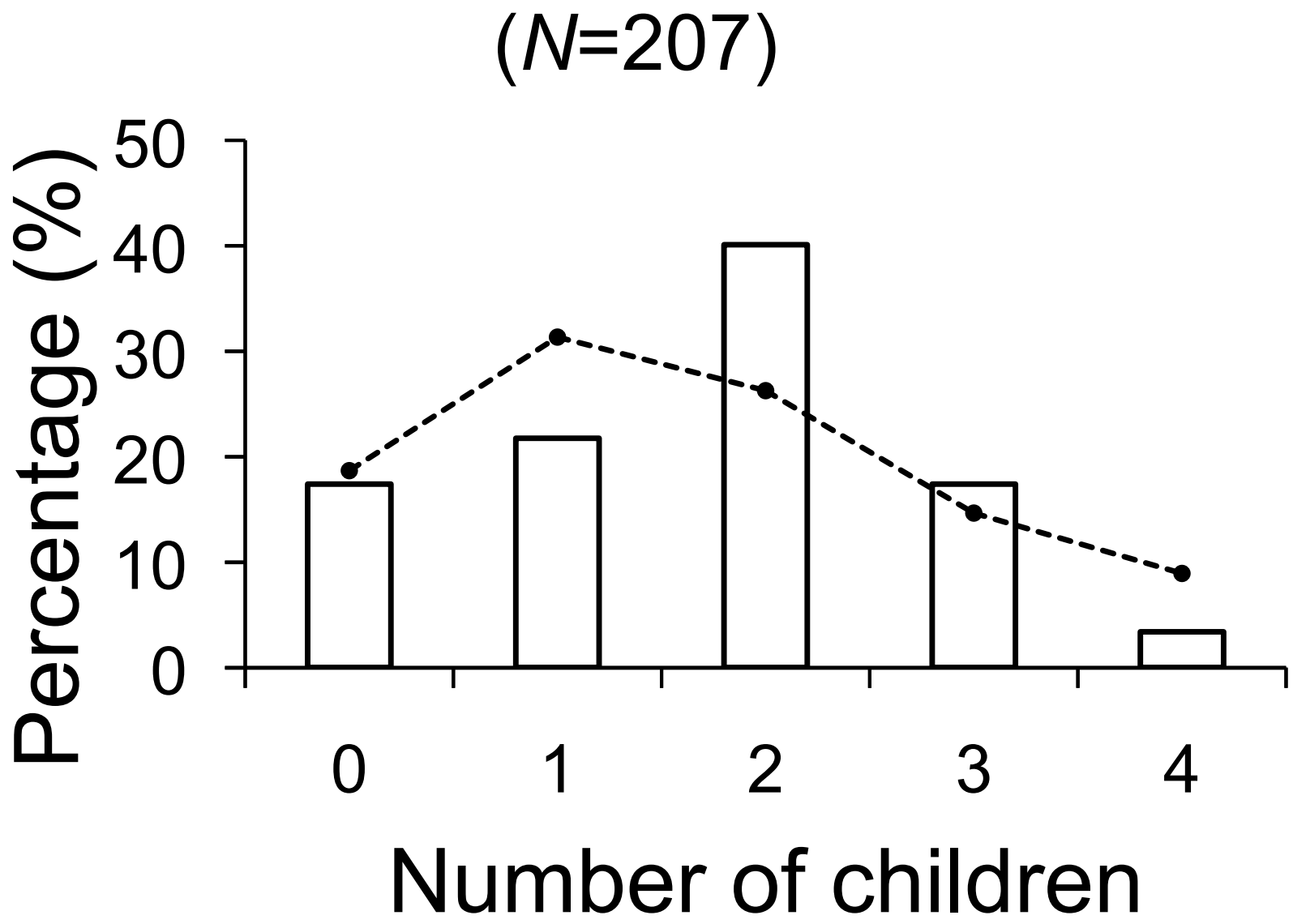

Fig. 2.1 The distribution of the number of children of individuals aged 45 or more

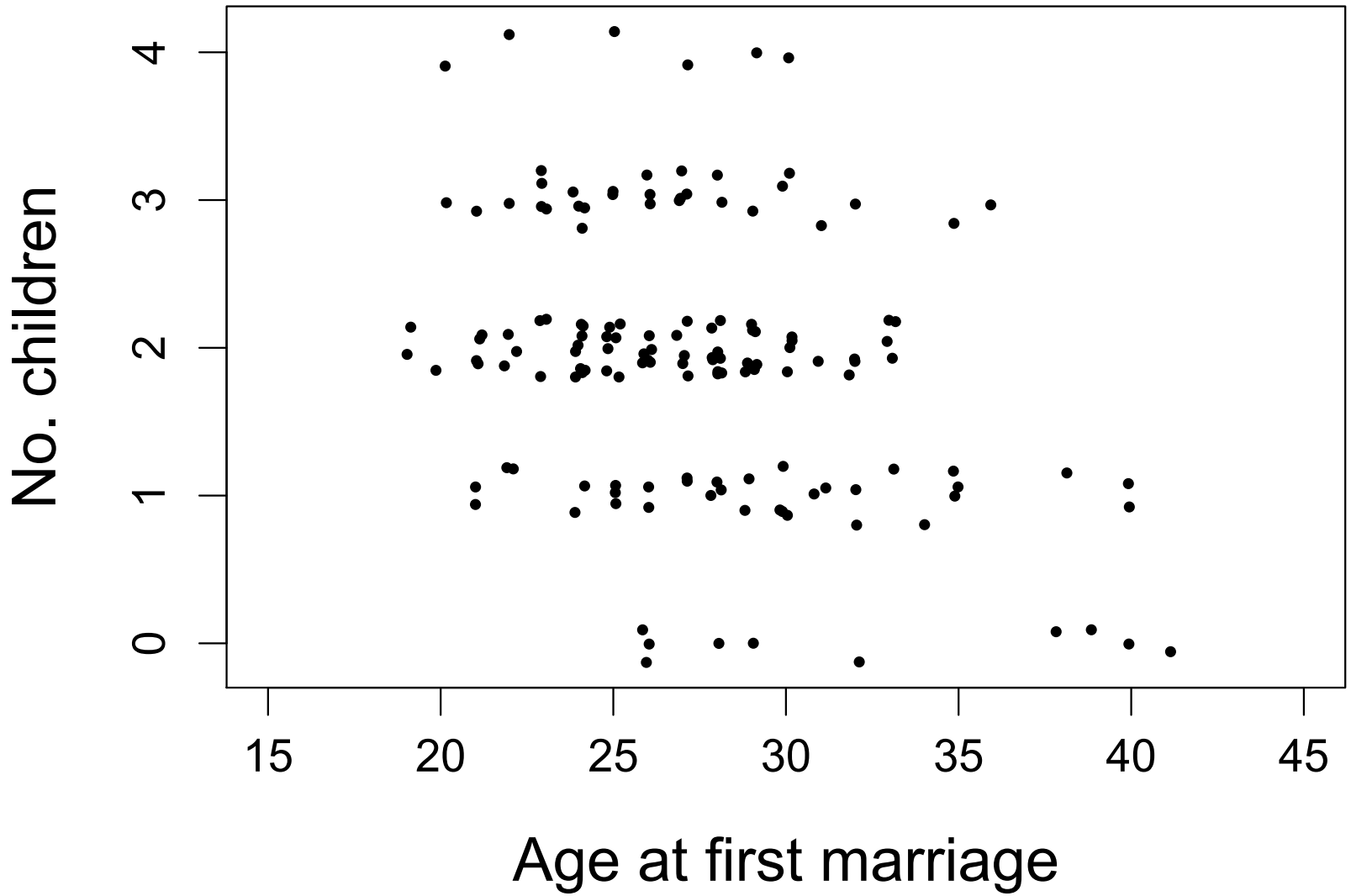

Fig. 2.2 The relationship between the age at first marriage and the lifetime number of children

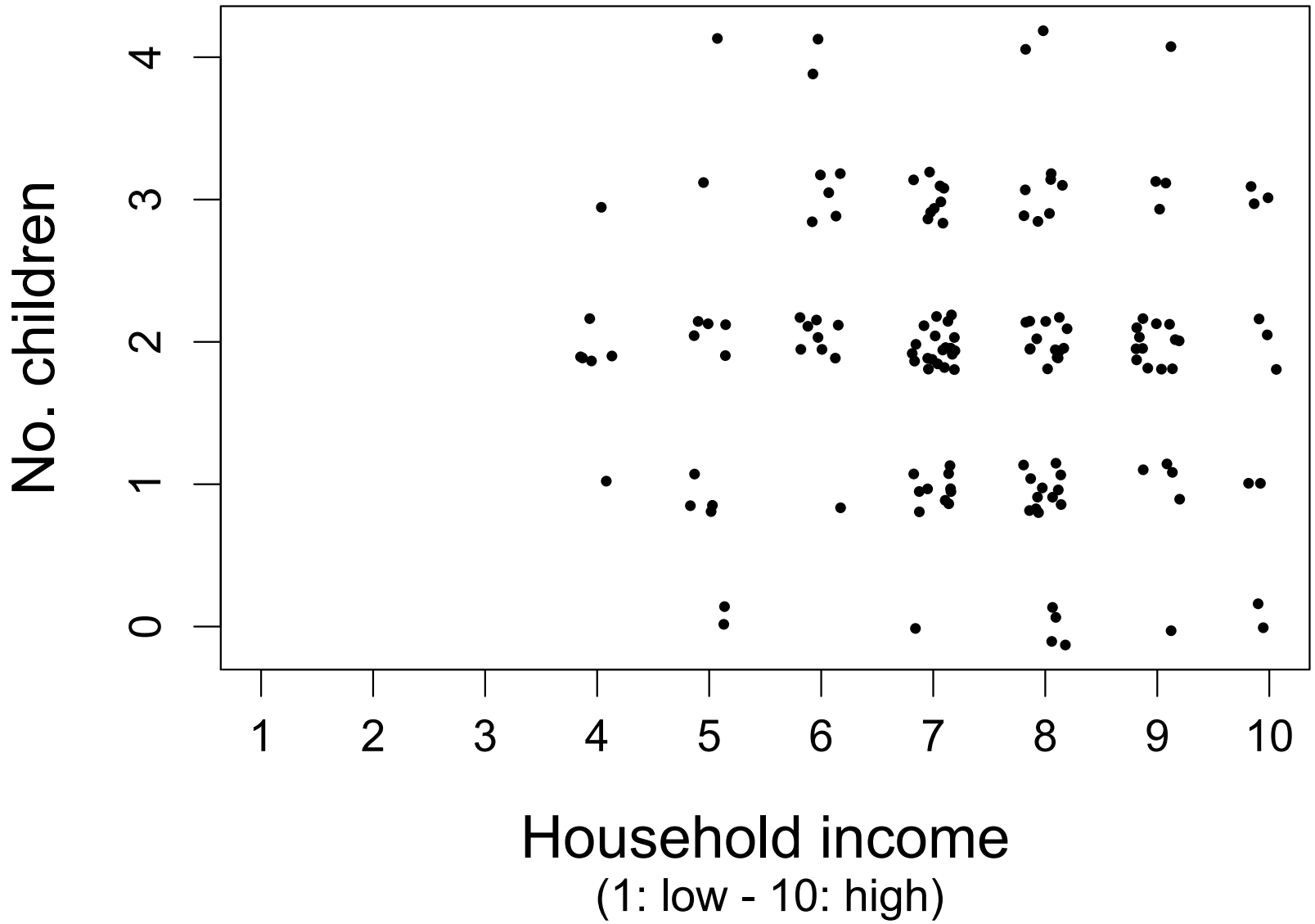

Fig. 2.3 The relationship between household income and the lifetime number of children

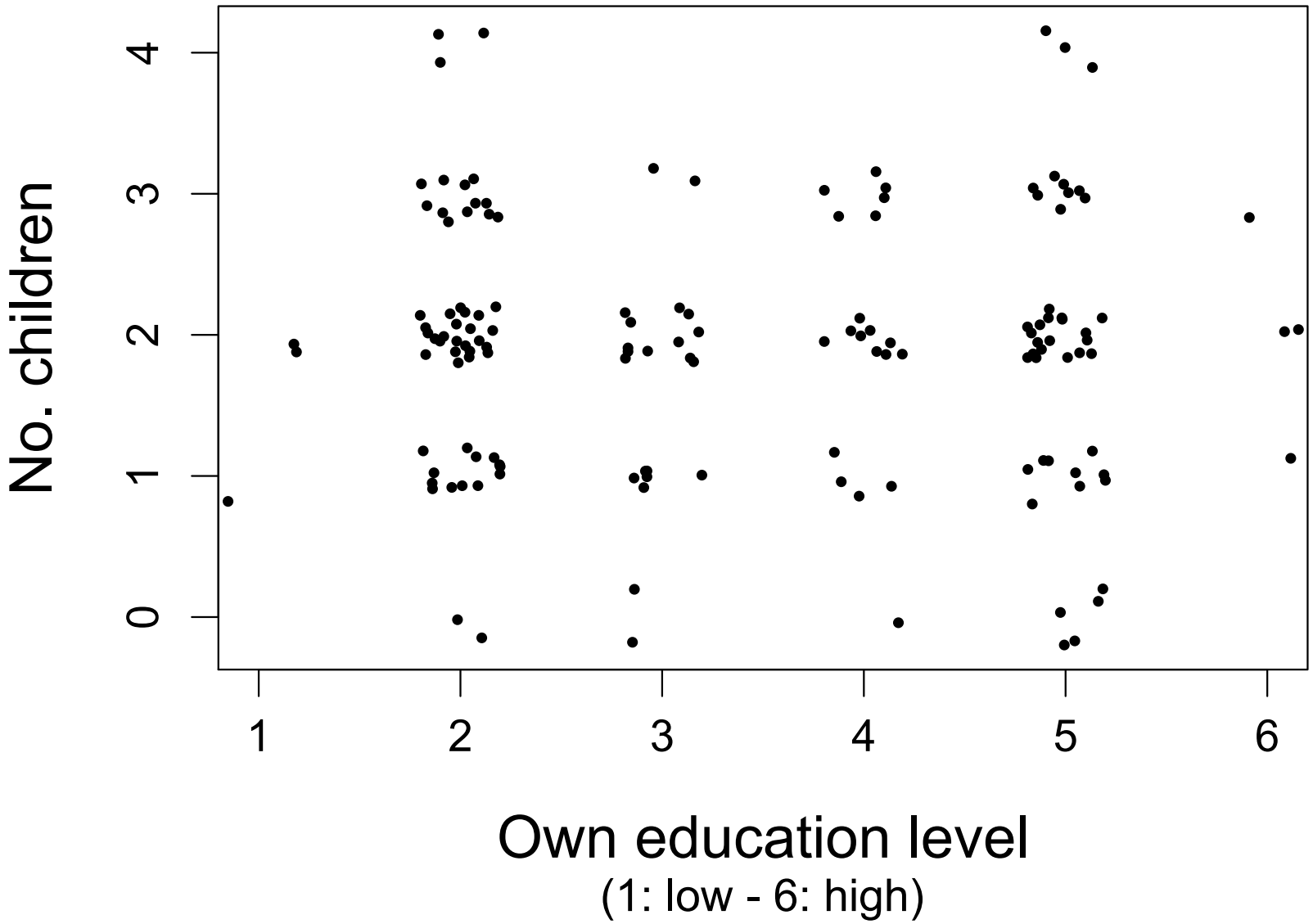

Fig. 2.4 The relationship between own education level and the lifetime number of children

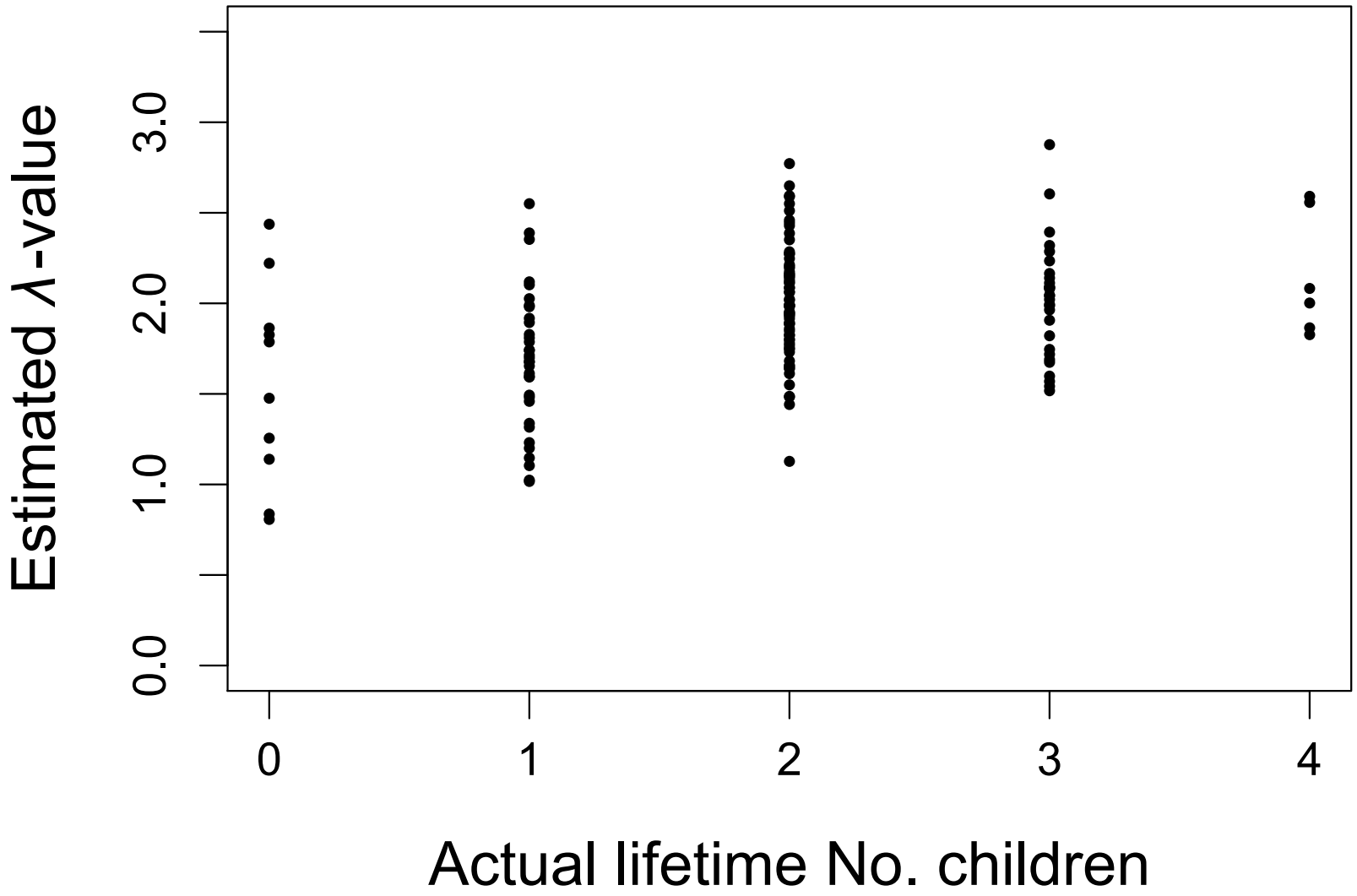

Fig. 2.5 The relationship between the actual lifetime number of children and the estimated λ-value of Poisson distribution

Table 2.1 A summary of factors affecting the number of offspring in modern developed societies

Subject				Measure	Factor[a]	Reference
Country	Year of data	Sex	Marital status			
Canada	1988-1989	men	married + unmarried	biological children	(/) social status[b]	Pérusse (1993)
USA	1990-1993	men	no information	lifetime biological children	(/) personal income	Kaplan et al. (1995)
				lifetime biological grandchildren	(-) personal income	
USA	1990s	men	married + unmarried	children	(-) education level	Kaplan et al. (2002)
		women			(-) education level	
USA	1985-1993	women	no information	lifetime children	(-) education level	Low et al. (2002)
Austria	2001	men	no information	children	(+) status[c]	Fieder et al. (2005)
		women			(-) status[c]	
		men	(excluding childless ones from the analyses)		(+) status[c]	
		women			(/) status[c]	
USA	1989-2000	men	no information	biological children	(+) personal income	Hopcroft (2006)
					(-) education level	
					(-) status[d]	
		women			(-) personal income	
					(-) education level	
					(-) status[d]	
USA	1990-2002[e]	men	no information	lifetime children	(/) personal income	Weeden et al. (2006)
					(-) education level	
		women			(-) personal income	
					(-) education level	
	2001-2002[f]	men		lifetime biological children	(+) personal income	

Table 2.1 continued

					(/) partner's income	
					(/) education level	
		women			(/) personal income	
					(+) partner's income	
					(/) education level	
Sweden	2000-2003	men	married + unmarried	lifetime biological children	(+) personal income	Fieder and Huber (2007)
					(+) education level	
		women			(-) personal income	
					(/) education level	
		men	(excluding childless ones from the analyses)		(/) personal income	
					(/) education level	
		women			(-) personal income	
					(/) education level	
(screen actors)	-2001	men	married + unmarried	biological children	(+) won Academy Awards	Hauber (2007)
		women			(+) won Academy Awards	
UK	1991-2004	men	married + unmarried	lifetime biological children	(+) personal income	Nettle and Pollet (2008)
					(-) education level	
		women			(-) personal income	
					(-) education level	
		men	(excluding childless ones from the analyses)		(/) personal income	
					(/) education level	
		women			(-) personal income	
					(/) education level	
Norway	1940-2003	men	married + unmarried	lifetime children	(+) education level	Kravdal and Rindfuss (2008)
		women			(-) education level	

Table 2.1 continued

Sweden	1915-2002	men	married + unmarried	lifetime biological children	(+) household income	Goodman and Koupil (2009)
					(+) education level	
					(+) socioeconomic position[g]	
				lifetime biological grandchildren	(/) household income	
					(-) education level	
					(+) socioeconomic position[g]	
		women		lifetime biological children	(/) household income	
					(/) education level	
					(/) socioeconomic position[g]	
				lifetime biological grandchildren	(/) household income	
					(-) education level	
					(/) socioeconomic position[g]	
USA	1980	women	married	lifetime children	(-) personal income	Huber et al. (2010)
					(-) education level	
					(-) partner's education level	
				for highly educated	(+) partner's income	
				for lowly educated	(-) partner's income	
13 EU	2004-2007	men	married + unmarried	lifetime biological children	(/ or +) personal income	Barthold et al. (2012)
					(-) partner's income	
					(-) education level	
		women			(-) personal income	
					(/) partner's income	
					(-) education level	
		men	(excluding childless ones from the analyses)		(-) personal income	
					(-) education level	

Table 2.1 continued

		women			(-) personal income	
					(-) education level	
USA	1990-1993[h]	men	married + unmarried	lifetime biological children	(+) income	Fieder and Huber (2012)
					(-) education level	
					(+) job position[i]	
		women			(-) income	
					(-) education level	
					(/) job position[i]	
		men	(excluding childless ones from the analyses)		(/) income	
					(-) education level	
					(+ or /) job position[i]	
		women			(-) income	
					(-) education level	
					(+ or /) job position[i]	
	1990[j]	women	married		(-) income	
					(-) education level	
			unmarried		(-) income	
					(-) education level	
Sweden	1915-2009	men + women	married + unmarried	lifetime biological grandchildren		Goodman et al. (2012)
				for male children	(+) socioeconomic position[g]	
				for female children	(/) socioeconomic position[g]	
				biological great-grandchildren	(/) socioeconomic position[g]	
				biological great-great-grandchildren	(-) socioeconomic position[g]	
			(excluding childless ones from the analyses)		similar trends as above	
Japan	2010	men + women	married	lifetime children	(/) household income	Morita et al. (2012)

Table 2.1 continued

					(/) education level	
Poland	2009-2010	women	married	children	(-) education capital	Colleran et al. (2015)
					(+) farming wealth	
					(+) non-farming wealth	
USA	2010	men	no information	lifetime biological children	(+) personal income	Hopcroft (2015)
					(-) education level	
		women			(-) personal income	
					(-) education level	
		men	(excluding childless ones from the analyses)		(/) personal income	
					(- or /) education level	
		women			(-) personal income	
					(-) education level	

[a] - (+): positive, (-): negative, or (/): null relationship

[b] - measured by personal income, education level, and occupation

[c] - measured by personal income, education level, and academic and administrative hierarchy

[d] - measured by intelligence, occupational status, and prestige

[e] - results from the GSS samples

[f] - results from the Harvard samples

[g] - measured by job type

[h] - results from the Wisconsin Longitudinal Study samples

[i] - measured by being a supervisory position or not / being in charge of hiring and firing or not

[j] - results from the IPUMS USA Census samples

Table 2.2 Descriptive statistics of each variable of subjects

(a) individuals aged 45 or more				
Variable	**Range**	**Mean**	**S.D.**	***N***
Age	45 - 49	46.48	1.15	(147)
Sex				
Male	-	-	-	57
Female	-	-	-	90
Age at first marriage	19 - 41	27.41	4.57	(147)
Household income (JPY)				
None	-	-	-	0
>1 M	-	-	-	0
≤1 to >2 M	-	-	-	0
≤2 to >3 M	-	-	-	7
≤3 to >4 M	-	-	-	13
≤4 to >5 M	-	-	-	16
≤5 to >7 M	-	-	-	40
≤7 to >10 M	-	-	-	39
≤10 to >15 M	-	-	-	22
≤15 M	-	-	-	10
Own education level				
Junior high school	-	-	-	3
High school	-	-	-	54
Vocational school	-	-	-	22
Junior college	-	-	-	20
University	-	-	-	44
Graduate university	-	-	-	4
Partner's education level				
Junior high school	-	-	-	4
High school	-	-	-	63
Vocational school	-	-	-	17
Junior college	-	-	-	9
University	-	-	-	50
Graduate university	-	-	-	4
Presence of housewife				
Absence	-	-	-	111
Presence	-	-	-	36

(b) all ages

Table 2.2 continued

Variable	Range	Mean	S.D.	*N*
Age	20 - 49	38.74	6.12	(673)
Sex				
Male	-	-	-	260
Female	-	-	-	413
Age at first marriage	16 - 42	26.97	4.22	(673)
Household income (JPY)				
None	-	-	-	1
>1 M	-	-	-	1
≤1 to >2 M	-	-	-	9
≤2 to >3 M	-	-	-	38
≤3 to >4 M	-	-	-	87
≤4 to >5 M	-	-	-	119
≤5 to >7 M	-	-	-	179
≤7 to >10 M	-	-	-	150
≤10 to >15 M	-	-	-	67
≤15 M	-	-	-	22
Own education level				
Junior high school	-	-	-	20
High school	-	-	-	228
Vocational school	-	-	-	115
Junior college	-	-	-	96
University	-	-	-	191
Graduate university	-	-	-	23
Partner's education level				
Junior high school	-	-	-	18
High school	-	-	-	258
Vocational school	-	-	-	99
Junior college	-	-	-	58
University	-	-	-	214
Graduate university	-	-	-	26
Presence of housewife				
Absence	-	-	-	415
Presence	-	-	-	258

Table 2.3 A summary of factors affecting the number of children

(a) Dependent variable was the lifetime number of children

(unit = person, distribution = 0: 10, 1: 34, 2: 68, 3: 29, and 4: 6)

Independent variable	Coefficient	S.E.	*z*	*P*
Sex (0: men, 1: women)	-0.167247	0.138264	-1.210	0.22643
Age at first marriage (years old)	-0.051610	0.016807	-3.071	0.00214
Household income (continuous)	-0.048775	0.044197	-1.104	0.26977
Own education level (continuous)	0.068721	0.056605	1.214	0.22473
Partner's education level (continuous)	-0.004811	0.050986	-0.094	0.92482
Presence of housewife (0: absence, 1: presence)	-0.087825	0.150073	-0.585	0.55840

The largest *r* was 0.4852 between own and partner's education level.

The residual deviance was 69.976 on 140 *df*.

(b) The age-adjusted number of children

(unit = person, distribution = 0: 96, 1: 176, 2: 281, 3: 105, 4: 12, and 5: 3)

Independent variable	Coefficient	S.E.	*z*	*P*
Age (years old)	0.038762	0.005043	7.175	<0.001
Sex (0: men, 1: women)	-0.106882	0.064198	-1.665	0.095937
Age at first marriage (years old)	-0.072065	0.008698	-8.286	<0.001
Household income (continuous)	-0.033219	0.022492	-1.477	0.139694
Own education level (continuous)	0.050710	0.028046	1.808	0.070593
Partner's education level (continuous)	-0.027899	0.025533	-1.093	0.274549
Presence of housewife (0: absence, 1: presence)	0.116341	0.065711	1.771	0.076643

The largest *r* was 0.5049 between own and partner's education level.

The residual deviance was 415.00 on 665 *df*.

Chapter 3

General title

Factors affecting the probability of childbirth: a statistical analysis of panel data

More specific title

A panel data analysis of the probability of childbirth in a Japanese sample: new evidence of the two-child norm

This chapter is based on Morita et al. (in press) that will be published in American Journal of Human Biology.

3.1. Abstract

In order to reveal the conditions that could facilitate childbirth in modern humans, it is necessary to analyze not only cross-sectional surveys but also panel data that track the same person for a long period. In this study, I explore factors that would influence the probability of childbirth. I analyze Japanese panel data by a statistical method called Cox proportional hazard model. Subjects of my analysis are married women and their childbirth records from 2004 to 2009. Contrary to the predictions based on the theory of behavioral ecology, I found no positive relationships between good parental conditions for childcare, such as high income, increase in income, or co-residence with parents (i.e., grandparents of children), and the occurrence of childbirth. I also found that the number of existing children had a significant impact on the probability of childbirth. The likelihood of further childbirth by couples with one child was nearly equal to that of childless ones. However, the corresponding likelihood of couples with two children was about five times lower than that of childless ones. The total fertility

rates in modern developed societies are quite low and couples prefer having two children. This trend is known as the two-child norm, but it is a paradoxical phenomenon in terms of fitness maximization. My result provides new quantitative evidence of this norm. This study revealed that the number of existing children being less than two was one of the crucial factors for further childbearing in my Japanese sample.

3.2. Introduction

3.2.1. Panel data analysis

To reveal factors responsible for the number of children, many previous studies analyzed cross-sectional data by assuming that one's reproductive success can be measured by his/her lifetime number of children at a certain threshold age, say at 45 (see also Chapter 2). Those studies analyzed the relationship between this number and the current status of samples (e.g., Alvergne and Lummaa, 2014; Barthold et al., 2012; Fieder and Huber, 2007; Goodman and Koupil, 2009; Hauber et al., 2010; Hopcroft, 2015; Kaplan et al., 1995; Kravdal and Rindfuss, 2008; Nettle and Pollet, 2008; Weeden et al., 2006). However, in these studies, there is a mismatch between when childbirth actually occurred and when people answered their status; the actual birth should have occurred much earlier than when they reached a threshold age (Barthold et al., 2012). The current status of samples, therefore, may have very little information about their past situations that should be much more important in order for us to predict childbirth. For example, rich people at the age of 45 were not necessarily rich when they bore a child.

On the other hand, I believe that analyzing panel data that track the same person for a long period can clearly reveal the conditions preceding childbirth that could have facilitated his/her childbearing, because such a method provides us with the information about their status on their life events. For example, Mathews and Sear (2013a,b)

analyzed a British panel survey and showed that the availability of kin positively affected the progression to childbirth. To list other examples, Schaffnit and Sear (2014) showed that the effect of kin on childbirth was modified by wealth. Tanskanen et al. (2014) explored which grandparent, maternal or paternal, and grandmother or grandfather, affected the probability of childbirth more (see also Rotering and Bras, 2015). Jokela (2010) focused on the effects of various characteristics (e.g., sex, prosociality, and cognitive ability) of the first child on the probability of bearing another child. However, to my knowledge, there are a limited number of panel data studies that analyzed human reproductive strategies that are related to fertility decline, possibly because there are only a small number of longitudinal panel surveys that are available to researchers.

The primary aim of this study is to identify factors that could affect the probability of childbirth. In particular, I study whether there is a positive relationship between good parental conditions for childcare and the occurrence of childbirth. Evolutionary theories predict that it is adaptive to bear more children when parental condition is good, because sufficient childcare is crucial for children's survival and growth. If good parental conditions for childcare actually have positive effects on the probability of childbirth, it means that my samples behave adaptively in terms of evolutionary theories. If not, I would conclude that their behavior is not necessarily adaptive in a modern environment, at least at a phenotypic level.

Candidate factors that may suggest good parental conditions are, for example, high income, increase in income, and/or co-residence with parents (i.e., living together with grandparents of the children). In social animals, it is expected that the amount of resources should be a critical factor determining their reproductive success (e.g., Barthold et al., 2012 Hopcroft, 2006, 2015, see also Ellis, 1995). In modern developed

societies, income is often used as one of the measures of one's resources (e.g., Hopcroft, 2006). I take into account not only the absolute amount of income but also its yearly changes, because I believe that the relative change in the amount of income can also be a psychological trigger for bearing a child. Co-residence with parents must be an important factor in terms of cooperative breeding (e.g., Sear and Coall, 2011; Sear and Mace, 2008); cooperative breeding is defined as the breeding system where not only parents but also others participate in childcare. Humans are cooperative breeders, and it is expected that co-residence with parents should enhance the probability of childbearing because couples can receive various supports from their parents.

3.2.2. Two-child norm

Additionally, I am interested in the two-child norm (e.g., Carey and Lopreato, 1995; Lopreat and Yu, 1988). In modern developed societies, it is well known that couples prefer having two children (e.g., Carey and Lopreato, 1995; Lopreato and Yu, 1988; Morita et al., 2012; Sobtka and Beaujouan, 2014). However, it is doubtful that this number, two, resulted from naive fitness maximization by parents, simply because it is too small. In Hutterites, a population that does not use modern birth-control methods, the average lifetime number of children was about 10 (Eaton and Mayer, 1953). This evidence indicates an upper physiological limit of human reproduction (see also Lee, 2003 for another evidence). Also, empirical studies showed that a higher number of children led to a higher long-term reproductive fitness, such as an increased number of grand- or great-grand- children (e.g., Goodman et al., 2012; Kaplan et al., 1995). Therefore, preferring two children is apparently maladaptive at least at a phenotypic level.

Thus, the second aim of this study is to quantitatively explore the effect of the number of existing children on the probability of further

childbirth. In my prediction, based on the two-child norm, the presence of two children should strongly prevent further childbirth. The two-child norm is a well-known phenomenon, but to my knowledge, its effect has not been quantitatively measured yet. Although in some previous studies (e.g, Mathews and Sear, 2013a,b) the authors analyzed the probabilities of the first and second childbirth separately, they did not systematically studied the effect of the number of existing children on further childbirth. In contrast, Tanskanen et al. (2014) studied the effect of the number of existing children on further childbirth (see their Appendix). However, they treated it as an ordinal factor in their statistical analysis, which means that they essentially assumed a *linear* effect of the existing number of children on further childbirth *a priori*. Contrary to Tanskanen et al. (2014), in this study I use the existing number of children as a categorical independent variable (see also Yamaguchi, 2004 for a related study that analyzed Japanese data). Therefore, I am able to study the effects of the presence of one child, two children, three children, and so on independently (without assuming a linear effect). By doing so, I will be able to quantify how strong the two-child norm is.

3.3. Methods

3.3.1. Data

The source data of my statistical analysis was the Japanese Panel Survey for Consumers, conducted by the Institute for Researches on Household Economics (further information is available at http://www.kakeiken.or.jp/en/JPSC/jpsc.html, last accessed on May 9th, 2015). This survey was annually conducted every September to women only. In this survey, subjects were chosen from all over Japan by stratified random sampling. I employed the Cox proportional hazard model (Cox, 1972), that is a statistical method of event history analysis. I restricted my sample to married women of age 40 or younger as of

September 2004, because the fraction of childbirth by unmarried women (i.e., the percentage of the number of illegitimate children) was very small in Japan (2.1% in 2009, Statistics and Information Department, Minister's Secretariat, Ministry of Health, Labour and Welfare, 2011). I analyzed their childbirth records from October 2004 to September 2009. I removed inappropriate individuals from my sample (such as ones with NA items; my procedure is described below in a more detail). As a result of this filtering, the data of 778 women were available for my statistical analysis. To conduct this study, I needed no ethical permissions.

3.3.2. Statistical analysis

To find factors that affect the probability of childbirth, I adopted the Cox proportional hazard model. In this model, I employed the occurrence of childbirth (binary; 0:absence(a birth did not occur) or 1:presence(a birth occurred)) in each annual survey period as the dependent variable. I focused only on one's first childbirth during the survey period (N=186). That is, if one gave multiple childbirths during the above-mentioned five-year observation period, I analyzed the first childbirth only and did not use the data after that. For example, if one had childbirth in 2005, I did not use this individual for the analysis of 2006 and later. In fact, there were 37 cases of multiple childbirths during the five-year observation period. I also removed individuals with inconsistent answers where one answered that she had childbirth but the number of her children did not increase by one, or vice versa, in order to avoid potential mistakes. As a consequence, I excluded the data with a twin or a triple, a death of children, or an adoption of stepchildren.

The way that I defined "period" and "occurrence of event" variables in the Cox proportional hazard model was as follows. For example, if one gave the first birth (not first in her lifetime but first between October 2004 and September 2009) in the second observation

year, her “period” was set to “2” and her “occurrence of event” was set to “present”. If one did not gave any childbirths during the five-year period, her “period” was “5” and her “occurrence of event” was set to “absent”.

I incorporated the following items as my time-dependent independent variables; subject’s age (unit=years; continuous), age squared (continuous; in order to avoid any artificial blow-up effects of age), the number of existing children (unit=person; categorical, I treated five or more as an NA item because of the rarity), subject’s occupation (binary; 0:absence or 1:presence including administrative leave), household income (i.e., the total income of the couple, unit=ten thousand JPY; numerical), the increase or decrease in the household income compared with the previous year (unit=ten thousand JPY; numerical), and co-residence with parents (binary; 0: they live far away / they passed away, or 1:they live together / in the neighborhood). As I explained, I analyzed only one’s first childbirth during the survey period. Therefore, the number of existing children was practically treated as a time-independent variable in this analysis. I also incorporated subject’s and her husband’s education levels (continuous; 7 levels from low to high) as time-independent control variables. Note that I used the household income, not woman’s or her husband’s personal income, because housewives are decreasing but still common in Japan, and because I believe that the total income of a couple should reflect their socioeconomic status more correctly. I did not study interaction effects among independent variables in my main analysis (but see also the Discussion section). I calculated Pearson’s *r* by using the data in 2004 (and the household income data in 2003 in order to study its increase or decrease; see the footnote of Table 3.2), to avoid excessive multicollinearity between independent variables. I did not control the duration of marriage of my sample, because such information was

available very little (see also the Discussion section).

I took a special care in choosing independent variables of an appropriate year so that each independent variable reasonably corresponds to childbearing in the focal year. For example, to explain a childbirth that occurred from October 2004 to September 2005, the following independent variables were chosen; age, the number of existing children, wife's occupation, co-residence with parents (all in September 2004), the household income (in year 2004), and the increase in income (between year 2003 and year 2004). Table 3.1 shows descriptive statistics of each variable. Because almost all husbands of my sample were employed (or in an administrative leave), I removed husband's occupation from my independent variables. I treated couple IDs as a random effect.

3.3.3. Procedures

I conducted the analysis of the Cox proportional hazard model using R version 2.15.2 for Mac OS X (R Core Team, 2012) with the *coxph* function in the *survival* package. Additionally, I used the *frailty* (gamma distribution, see also Mills, 2011) and *unfold* functions (Fox and Weisberg, 2011). I confirmed the proportionality of hazards by using the *cox.zph* function in the *survival* package.

3.4. Results

I showed a summary of my analysis of the Cox proportional hazard model in Table 3.2. Among the independent variables that were studied, I found that age, age squared, number of existing children, own occupation, and household income had significant (i.e., $P<0.05$) impacts on the probability of childbirth. Also shown in Table 3.2 were hazard ratios (i.e., the exponential of coefficients), that is, the relative likelihood of further childbirth per unit increase of each variable. Below

I will describe the details of the result.

3.4.1. The effect of women's age

According to the estimated regression coefficients of age (1.044957) and age squared (-0.018920), the probability of childbirth was estimated to be the highest at 27.6 years old.

3.4.2. The effect of women's occupation

The regression coefficient of the presence of occupation was significantly negative (-0.458356), suggesting that the presence of occupation suppressed childbirth for women. The hazard ratio of childbirth of women with an occupation relative to that of housewives was 0.632, suggesting that employed women are roughly two-thirds as likely to give birth as unemployed women.

3.4.3. The effect of household income

I found that the household income had a significantly negative effect on childbirth; that is, the higher the household income was, the less likely they bore a child. Note that a tiny negative value of its regression coefficient (-0.000686) did not suggest that its effect size was also small. Rather it was simply because the household income was measured in such a small unit as ten thousand JPY in my analysis. Its chi-squared value (3.88) provided a comparative statistic with other independent variables, and the household income had indeed a significantly negative effect on childbirth. The yearly increase or decrease in the household income had no significant effects.

3.4.4. The effect of co-residence with parents

Contrary to my prediction, co-residence with parents had no significant positive effect on the probability of further childbirth.

3.4.5. The effect of the number of existing children

The presence of two or three children had significantly negative effects on the probability of further childbirth. Importantly, however, the existence of one child had no significant impact on further childbirth. The hazard ratio of couples with one child bearing the second child, relative to childless couples bearing the first child, was nearly equal to unity (0.921). On the other hand, the hazard ratio of couples with two children bearing the third child, relative to childless couples bearing the first child, was 0.220. This result indicated that the likelihood of further childbirth of couples with two children was about five times lower than that of childless couples. The hazard ratio of couples with three children bearing the forth child, relative to childless couples bearing the first child, was 0.404, but this estimate was not statistically significantly different from one. Therefore, this result does not necessarily indicate that the probability of childbirth of couples with three children (the hazard ratio was 0.404) was higher than that of couples with two children (the hazard ratio was 0.220).

3.5. Discussion

In this study, I explored factors influencing the probability of childbirth. I assumed that a high household income, an increase in the household income, and co-residence with parents should reflect good parental conditions for childbirth and childcare. However, they did not have significantly positive effects on the probability of childbirth. On the contrary, the absolute amount of household income had a negative effect. These results seem paradoxical from the perspective of behavioral ecology, because good parental conditions did not have positive effects on the probability of childbirth.

I found that women's age and the presence of an occupation were

significant factors that affected childbearing; advanced ages and the presence of an occupation suppressed childbirth. These results seem reasonable. I presume that some kinds of physiological restriction can suppress childbirth with aging. Also, working outside the home should make it difficult for women to find the time for childcare, hence can lead to a low birth rate (see also Snopkowski and Kaplan, 2014 for an example showing labor force participation of women delayed their first childbirth; Brewster and Rindfuss, 2000 for a review of this effect). Moreover, women may find much rewarding in their job and postpone their reproduction. I caution, however, that the retirement due to childbirth, not the other way around, can also be reflected in my result. The negative effect of the presence of occupation can also be understood from the perspective of social learning. Individuals who work outside the home may often be exposed to some social or cultural norms that favor a small number of children (cf. Shenk, 2009; Shenk et al., 2013). Such an environment surrounding working women can potentially suppress the probability of further childbirth.

Another possible argument explaining my result is that the household income has a negative effect on childbearing if and only if mothers are employed, and that it could have a positive effect if mothers do not work. I therefore studied the interaction effect between the household income and the presence of occupation. However, I found that the interaction effect was not significant (P=0.37 but details not shown here; cf. Van den Broeck and Maertens, 2015). It could be the case that unemployed mothers in a wealthy family do not take advantage of their situation very well. It is interesting to study not only socioeconomic conditions of parents but also how they perceive their status.

My result also showed that the presence of two children strongly prevented further childbirth (cf. Yamaguchi, 2004). As I mentioned in the introduction, two is too small a number to be considered as a result

of fitness maximization by parents (e.g., Goodman et al., 2012; Kaplan et al., 1995; Lawson et al., 2012). In this study, I presented a new quantitative piece of evidence of the two-child norm by showing that the presence of two children reduced the probability of further childbirth by one fifth in a Japanese sample in this cohort survey. In a next step to study the two-child norm, I will also have to clarify its ultimate factor. In previous studies, several factors that can be responsible for the two-child norm have been proposed; trade-offs between offspring quality and quantity, the cost benefit balance of childcare, the decrease in child mortality rates, the effect of cultural norms, and so on (e.g., Carey and Lopreato, 1995; Lopreato and Yu, 1988; Morita et al., 2012; Sobtka and Beaujouan, 2014). Lawson and Mace (2010) found that mothers at a middle or high socioeconomic status perceived higher economic hardship with three children relative to when they had two children. The perception of higher cost of bearing more than two children may prevent people from bearing the third child. Shenk (2009) and Shenk et al. (2013) showed that a lower infant mortality rate was related to a smaller number of children. However, this trend does not necessarily explain the preference for "two" children. It is also known that one's reproductive decision-making can be affected by others (see Colleral et al., 2014 for a recent example), so there can be some cultural or social norms shaping the preference for the number of children. However, it has not been solved yet why such norms arose or why people adopt these norms. The puzzle of the number of two still remains.

My findings confirm what was previously found in cross-sectional studies, that there does not exist a positive relationship between one's socioeconomic success and his/her reproductive success. In my analysis, assumed good parental conditions for childcare did not have positive effects on the probability of childbirth. Refraining from bearing more than two children is maladaptive from the viewpoint of evolutionary

theories, because if parents continued reproduction, they could obtain more reproductive success. It could be the case that the good parental conditions that I assumed did not reflect genuinely good conditions for parents. It would be beneficial to study in the near future how parents perceive their socioeconomic conditions and how they relate them to their decision on childbearing (see also Chapter 6).

There exist some limitations in my study. First of all, my analysis has revealed the correlation between parental conditions and childbearing, but not their causality. It remains to be important to clarify whether and how each factor affects parents' decision-making on childbearing. Speaking of methodological aspects, I analyzed the linear effect of household income on the likelihood of childbearing in my Cox proportional hazard model. However, the likelihood may not monotonically increase with the household income; the dependence could be hump-shaped. It is one of my future works to deal with household income with an appropriate discrete categorization to study its effect more carefully. I found no significant effect of co-residence with parents on the probability of childbirth. However, it is not clear if parents living together or nearby actually help their sons and daughters take care of their children. Understanding what they provide for childcare and how they do so should also be important (cf. Snopkowski and Sear, 2013). For example, the presence of old parents who need nursing cares may be costly, not beneficial, for couples (Sear and Coall, 2011). Also, it is reported that the role of parents (i.e., grandparents of children) differed according to their relation to their grandchildren (such as maternal/paternal and grandmother/grandfather, cf. Rotering and Bras, 2015; Tanskanen et al., 2014). However, I did not include those detailed distinctions in my study. A similar limitation is found in my treatment of women's occupation, where I simply used a binary measure, employed or not. However, in order to reveal the effect of occupation more precisely,

I have to investigate more detailed characteristics of their occupation. For example, whether the employment is limited-term or permanent should be critical in their decision-making on bearing a child. Another limitation of my current analysis is that I could not statistically control the effect of women's age at marriage, their marriage period, or their postpartum period from the previous childbirth. This is equivalent to assuming that the likelihood of childbirth was the same among all subjects regardless of the duration of their marriage period or postpartum period. To improve the resolution of my study, it is necessary to analyze longer-term data that trace couples from immediately after their marriage or that include sufficient information about their age at marriage and/or marriage period. In addition, my results are based on a study of a Japanese sample in a single cohort survey, so it is not appropriate to interpret my results as a human universal. Results may differ if one studies samples from other countries, or even other Japanese samples.

Although there exist some theoretical and methodological limitations in my study, I believe that my attempt to reveal the parental conditions that are correlated with childbirth, presented in this paper, has provided a useful piece of information for understanding human reproductive strategies.

Table captions

Table 3.1. Descriptive statistics of my sample used in the analysis.

Table 3.2. A summary of the analysis of the Cox proportional hazard model.
In the column with the heading "Coefficient", I show regression coefficients of each factor on the likelihood of childbirth.

Data accessibility

Researchers can access the original data of the survey by obtaining the permission from the institute that conducted and managed the original survey (see http://www.kakeiken.or.jp/en/JPSC/jpsc.html for details, last accessed on May 9th, 2015). However, I cannot make the raw data that I analyzed in this paper open access, because of the agreement with the institute. More information is available personally by contacting the author.

Table 3.1 Descriptive statistics of my sample used in the analysis

Variable	Range	Mean	S.D.	*N*
Age	25 - 40	33.06	4.30	(778)
Number of existing children				
0	-	-	-	129
1	-	-	-	187
2	-	-	-	333
3	-	-	-	118
4	-	-	-	11
Occupation				
absence	-	-	-	386
presence (including administrative leave)	-	-	-	392
Household income (ten thousand JPY)	0 - 4202	617.15	341.20	(778)
Change of household income (ten thousand JPY)	-3200 - 2941	12.67	238.35	(778)
Co-residence with parents				
living far away / passed away	-	-	-	104
living together / in the neighborhood	-	-	-	674
Own education level				
Junior high school	-	-	-	30
Vocational school (after JHS graduation)	-	-	-	12
High school	-	-	-	318
Vocational school (after HS graduation)	-	-	-	142
Junior college/technical college	-	-	-	176
University	-	-	-	97

Table 3.1 continued

Graduate university	-	-	-	3
Husbands' education level				
Junior high school	-	-	-	70
Vocational school (after JHS graduation)	-	-	-	7
High school	-	-	-	334
Vocational school (after HS graduation)	-	-	-	86
Junior college/technical college	-	-	-	37
University	-	-	-	232
Graduate university	-	-	-	12

Statistics are based on the data in 2004 (and the household income data in 2003 in order to study its increase or decrease).

Table 3.2 A summary of the analysis of the Cox proportional hazard model

Independent variable	**Coefficient**	**S.E.**	**exp (coef)***	χ^2	***P***
Age (years old)	1.044957	0.352940	2.843	8.77	<0.01
Age squared	-0.018920	0.005434	0.981	12.12	<0.001
Number of existing children (ref:0)					
1	-0.082598	0.198168	0.921	0.17	0.68
2	-1.515033	0.232028	0.220	42.63	<0.001
3	-2.186699	0.485663	0.112	20.27	<0.001
4	-0.906546	0.776839	0.404	1.36	0.24
Occupation					
presence	-0.458356	0.167278	0.632	7.51	<0.01
Household income (ten thousand JPY)	-0.000686	0.000348	0.999	3.88	<0.05
Change of Household income (ten thousand JPY)	0.000039	0.000436	1.000	0.01	0.93
Co-residence with parents					
living together / in the neighborhood	0.085573	0.235892	1.089	0.13	0.72
Own education level	0.066099	0.070003	1.068	0.89	0.35
Husbands' education level	0.042472	0.058887	1.043	0.52	0.47

The largest *r* was 0.4653 between own education level and husbands' education level.

*exp (coef): exponential of coefficient

Chapter 4

General title

Sexual conflict between mother and father over reproductive decision-making: a questionnaire survey

More specific title

Does sexual conflict between mother and father lead to fertility decline? A questionnaire survey in a modern developed society

This chapter is based on Morita et al. (accepted) that will be published in Human Nature.

4.1. Abstract

Fertility decline is a great challenge to evolutionary approaches to human behavior. In this study, I apply the perspective of sexual conflict between mother and father to the fertility decline. It is predicted that, under serial monogamy that allows mate changes, the ideal number of children for women should be smaller than that for men, because the cost of reproduction for women should be higher than that for men. My reasoning is that if the cost of child-bearing and child-caring is higher in women than men, and if women, who want a smaller number of children than their husbands, have gained more power in reproductive decision-making within a couple owing to the modernization of the society, fertility decline should occur. Until now, few evolutionary studies have analyzed empirical data in modern developed societies with such a perspective. My questionnaire survey in an urban area in Japan revealed that mothers actually experienced greater cost during childcare than fathers. However, in contrast to my prediction, I found no sex

differences in the ideal number of children between mothers and their husbands in many cases. About 60% of parents wanted two children when they were childless. Moreover, my analysis showed that mothers and their husbands had equal power in their decision-making to bear children. Following these results, I discuss some perspectives towards an understanding of fertility decline in terms of sexual conflict.

4.2. Introduction

4.2.1. Sexual conflict between mother and father

In addition to the original hypotheses by Borgerhoff Mulder (1998) that I explained in Chapter 1, here I focus on the sexual conflict between mother and father. Sexual conflict is defined as a conflict of reproductive interests between the two sexes (e.g., Arnqvist and Rowe, 2005a). In non-human animals, sexual conflict is a general feature. The conflict over parental care is a good example. By providing a parental care, parents obtain the benefit of reproductive success, but they sacrifice their own survival and future reproduction instead. Therefore, in certain situations, each parent may rely on the parental care by the other, which can often lead to a mate desertion. It is often the case that in animals with biparental care, males, the sex that usually provides a smaller amount of parental investment, put more effort in mating with extra females but less in taking care of their current offspring (Arnqvist and Rowe, 2005b; Chapman et al., 2003, see also Kokko and Jennions, 2008).

Shackelford et al. (2012) pointed out that, in previous human studies, a human couple was often viewed as a cooperative unit with common reproductive goals. For example, Mason and Taj (1987) noted that there were few fertility surveys that studied participants of both sexes. However, I believe that reproductive interests between males and females should differ in humans, too (e.g., Shackelford and Goetz, 2012).

In this study, therefore, I analyze fertility decline from the perspective of sexual conflict between mother and father.

In this paper, I analyze the sex difference in the ideal number of children. Biologically, it is well known that the cost of reproduction for women is higher than that for men (Penn and Smith, 2007; Trivers, 1972), so the ideal number of children for women should be smaller than that for men (reviewed in Borgerhoff Mulder and Rauch, 2009). However, the cost of reproduction is not the sole determinant of the ideal number of children. In fact, another review (Mason and Taj, 1987) showed that the sex difference in the ideal number of children in developing countries was small (see also Burbank and Chisholm, 1992). Mason and Taj (1987) suggested possible reasons for this. For example, the improvement of women's health and the reduced cost of reproduction for women in modern economic and demographic conditions may lead to the same number of ideal family size for women and men. To better understand the sex difference in the ideal number of children, I believe that, in addition to the cost of reproduction, the effects of divorce, mating system, and marriage stability should be considered more (Borgerhoff Mulder and Rauch, 2009), because these factors can yield the sex difference in the cost of reproduction within a couple.

4.2.2. Mating system and sexual conflict

It has been suggested that under complete monogamy, there should be no conflicts of reproductive interests in family size between the two sexes (Barkow and Burley, 1980; Mace, 1996, see also Bankole and Singh, 1998; Dodoo and Seal, 1994 for related empirical examples). It is because the cost and benefit of reproduction for one sex completely agrees with those of the other sex if a mate change never occurs. As data to indirectly support this idea, it has been reported that in a Kenyan agropastoralist society, where polygyny is frequent but the marriage is

quite stable and divorce is rare, men wanted more children, *per individual*, than women, but they wanted a similar number of children, *per wife*, to that of women (Borgerhoff Mulder and Rauch, 2009).

On the other hand, Borgerhoff Mulder (2009a) showed that the ideal number of children for women was smaller than that for men in a horticulturalist society in Tanzania. In this tribe, they have unstable marriage, little polygyny, and a high divorce rate. Under such *serial monogamy*, which is defined as a mating system where one can marry another partner only after divorce or bereavement, it is predicted that men should want more children than women. It is because the inherent biological asymmetry in the cost of reproduction between men (providing sperms) and women (providing ova, getting pregnant, and giving childbirth and breast-feeding) actually enables men to have more reproductive advantage by changing their sexual partner than women under serial monogamy (see also Borgerhoff Mulder, 2009b; Brown et al., 2009; Jokela et al., 2010; Pettay et al., 2014; Skjærvø and Røskaft, 2014). In fact, a study in the modern United States showed that there was a greater reproductive advantage in men under serial monogamy; it is reported that men who mated with more women had more children in total (Jokela et al., 2010). However, the opposite result was also found; in the above-mentioned horticultural population in Tanzania, one's reproductive fitness and the number of spouses were negatively correlated in men (Borgerhoff Mulder, 2009b).

These conflicting pieces of evidence show that mating system only partly explains the pattern of the sex difference in the ideal number of children; I need more studies to accumulate more empirical evidence (Brown et al., 2009, see also Gowaty et al., 2012). A goal of this study is thus to investigate the sex difference in the ideal number of children between parents in terms of power balance in reproductive decision-making within a couple in current Japan. Until now, few studies

have been conducted with such a perspective in modern developed and low-fertility societies. Therefore, I believe that my study will contribute to revealing the effect of sexual conflict on the fertility decline and reproductive decision-making in humans in general.

4.2.3. Hypothesis and predictions

In most modern developed societies including Japan, serial monogamy is adopted as a legal mating system. According to the abovementioned previous study in the modern United States (Jokela et al., 2010), I expect that, under serial monogamy, men would generally want more children than women. It is because the cost of reproduction for men actually becomes smaller than that for women and therefore men could have more reproductive advantage by changing their sexual partner. In fact, there were 6679 cases of divorce to 20299 cases of marriage in my study area (see the Method section for details) in 2013 (according to the website of study area, http://www.city.yokohama.lg.jp/ex/stat/, last accessed on 24th April, 2015), supporting my view that divorce can actually be an important factor in Japan (but see also the Discussion section).

In this study, I focus on the fertility decline in Japan since the 1970s. The social environment surrounding women changed dramatically during that period. For example, a large movement for women's liberation began in Japan around 1970. The equal employment policy for women was legally established in 1972. In addition, the fertility rate continuously declined for more than 30 years since 1970 (the total fertility rate was 2.13 in 1970, 1.76 in 1985, 1.36 in 2000, and 1.26 in 2005, Statistics and Information Department, Minister's Secretariat, Ministry of Health, Labour and Welfare, 2011; although it has increased slightly in recent years probably owing to the increasing social support for childcare by the government). As I explained earlier, under serial

monogamy, the ideal number of children for women should be smaller than that for men. It is therefore possible that the fertility decline since 1970s can be partly explained by a shift in power balance within a couple; namely, that women currently have become to gain more, rather than equal, power in reproductive decision-making (see also the Discussion section).

In order to explain these transitions, I hypothesize that the modernization of the society caused women, who would generally want a smaller number of children than their husband, to gain more power in reproductive decision-making within a couple and that it led to the fertility decline in Japan (see also Barkow and Burley, 1980; Borgerhoff Mulder, 2009a; McAllister et al., 2012; Penn, 1999; Penn and Smith, 2007). In particular, I make three predictions: that (1) women should experience greater cost during childcare than men, that (2) the ideal number of children for women should be smaller than that for men, and that (3) women should currently have more power in reproductive decision-making than men.

Barkow and Burley (1980) emphasized and reviewed the idea of the sex difference in the ideal number of children and its effect on fertility decline, with the social progress of women taken into account. Although they did not provide systematic data to directly test their hypothesis, they concluded through their theoretical model that (1) the evolutionarily optimal number of children for the two sexes should not differ in most cases, and that (2) in order for men to maximize their reproductive fitness, they should not force women to bear more children than women's optimal level. However, I think that their conclusion was premature. They considered the same trade-off for both sexes between offspring quality and quantity in their model. However, the sex difference in the cost of reproduction can lead to different trade-offs between sexes. For example, having a larger number of children may

have more negative effect on a long-term fitness for women than men. Therefore, I think that it is necessary to collect sufficient empirical evidence to prove or disprove their model assumptions.

The relationship between gender equality and fertility decline has been argued in previous literature. Some previous studies concluded that gender equality led to a low birth rate, (e.g., McDonald, 2000) but other studies drew the opposite conclusion (e.g., Toulemon, 2011). However, to my knowledge, few evolutionary studies on fertility decline analyzed empirical data in modern, developed, and low-fertility countries with the perspective of sexual conflict (cf. Moya, C., Snopkowski, K. and Sear, R., personal communication, working title: Sexual conflicts of interests in reproductive decision-making in humans).

In addition, in order to gain basic information about reproductive decision-making by couples, I also investigate potential factors that affect the ideal number of children for parents. For example, I analyze whether a higher household income and/or a lower cost of childcare lead to a larger ideal number of children.

4.3. Methods

4.3.1. Study site and data collection

I conducted a questionnaire survey to parents at a childcare facility in an urban area in Yokohama City, Kanagawa Prefecture, Japan. Parents and their children visit this site for playing and talking freely with each other. Childless couples rarely visit this site except for special occasions. The average total fertility rate in Japan in 2013 was 1.43, but it was only 1.31 in Yokohama City. As background information, the sex ratio of men to women in Yokohama city was 1.07 among people between age 15 and 44 in 2012 (according to the website of Yokohama City, http://www.city.yokohama.lg.jp/ex/stat/, last accessed on 14th April,

2015).

The total period of questionnaire survey was 18 days from October to December in 2013. I handed out questionnaires to parents visiting the site to ask about their marriage, childbirth, and childcare, after explaining a general (but not specific) purpose of my survey. I asked them (mostly, mothers) to answer questions at their home with their spouse (but separately without having a discussion; see below). I prepared two separate but identical questionnaire sheets, one for mother and the other for father, and asked them to answer the questionnaire separately and independently without any discussion with each other.

Some examples of my questions were *"What do/did you feel during childcare?"* (multiple choices allowed out of 14 choices in total; they were, for example, time, economic, physical, and mental cost), "*How many (additional) children do/did you want?*" (answer in a number or "do/did not want any"), "*Who had more power in deciding whether to have children, you or your spouse?*" (one choice allowed: you only, both but you more, both equally, both but your spouse more, your spouse only, or neither (i.e., neither parent wanted children)), and "*Who desired more for having children, you or your spouse?*" (one choice allowed: you only, both but you more, both equally, both but your spouse more, your spouse only, or neither). Participants were required to answer not only their current situations, but also the past ones. For example, to parents currently with two children, I asked in a following way; *"Before having the second child, what did you think about…?"*. I show the questionnaire sheets (in Japanese) used in this study in the Appendix.

I decided the procedure and items of the questionnaire after a preliminary survey at another childcare facility in 2012. I collected questionnaire sheets by using the mailing method. The reward given to participants was 1000 JPY per person. Eventually, 387 persons (195 couples) returned their questionnaire (the response rate was about 55%).

This study was approved by the ethical committee of SOKENDAI (see my ethics statement for details).

4.3.2. Participant characteristics

Participants who had either divorced or lost their spouse (N=6 for mothers and N=9 for fathers) were excluded from my analyses because they must have been in a quite different situation from others (see also the Discussion section). Also, participants who did not answer their nationality, those who answered they were not Japanese, or the couples where either one of them did not answer the questionnaire, were excluded. As a result, my final sample size ended up with 346 persons (173 couples).

Ages of mothers were from 20 to 43 years old (mean: 33.3, S.D.: 4.59) and ages of fathers were from 19 to 56 years old (mean: 34.4, S.D.: 5.45). Their ages at marriage were from 18 to 38 years old (mean: 27.9, S.D.: 3.71) for mothers, and from 18 to 49 years old (mean: 29.3, S.D.: 4.83) for fathers. Most couples had one or two children at the time of the survey (1: 65.9%, 2: 26.6%, and 3 or more: 7.51%) and children's ages were from 0 to 14 years old. The proportion of households in which mothers did not have an occupation (i.e., housewife family, except for administrative leave) was 68.2%. As for the education level, 43.9% of mothers and 65.3% of fathers were university graduates or with higher education. I summarized other detailed descriptive statistics of participants in Table 4.1. In this paper, I showed results of analyses after excluding not available (NA, mostly, missing) data.

4.3.3. Statistical analysis

To examine the sex differences in (1) the perception of the cost during childcare and in (2) the ideal number of children, I performed chi-squared and binomial tests. In multiple comparisons, I adjusted

p-values according to Holm (1979). To identify factors that are responsible for the ideal number of children, I used the generalized linear mixed model (GLMM), where I assumed that the error structure was given by a Poisson distribution.

I used the ideal number of children (unit = person, continuous) as the dependent variable in my GLMM analyses. The following items were employed as the independent variables: sex (binary), own age (continuous), annual household income (8 levels, continuous), own education levels (5 levels, continuous), the presence of housewife (binary), and the number of own siblings including self (unit = person, continuous). For the analysis of parents at the time when they had one or two children, their past perception of various types of cost during child-caring (whether or not they experienced time, economic, physical, or mental cost) was also included as independent variables (binary for each). I treated couple as a random effect (intercept) and incorporated interaction terms between sex and the other independent variables.

There are some remarks on my independent variables. First, if the mother and the father in the same couple answered different household income levels (see Table 4.1), I treated the data in the following way; if they differed by two levels or more I excluded the couple from my GLMM analyses, but if they differed by only one level (this was the case for N=17 couples), I assumed that the small difference occurred due to a misunderstanding and that the income level answered by the mother was the correct one. It is because I presumed that mothers would know more about the family budget than their husbands in many cases (e.g., Kamiya, 2010 for an example that studied financial management in Japanese families). Second, although I asked about various kinds of cost during childcare, I studied only four of them (time, economic, physical, and mental cost) in my statistical analyses. It is because I supposed that those four must be major and general among all

participants. Before the GLMM analyses, I calculated Pearson's *r* to check multicollinearity between independent variables (see the footnotes of Table 4.3). I excluded participants from the GLMM analyses if they or their spouse had an NA item. All statistical tests were conducted by R version 2.15.2 for Mac (R Core Team, 2012). For my GLMM analyses, I used the *glmmML* function in R.

4.4. Results

4.4.1. Preference for the number of children

First, I show the preference for the number of children. I asked mothers and fathers how many children they wanted when they had no children. About 60% of them answered two (Figure 4.1). This result indicated that parents preferred two children.

4.4.2. Did women experience greater cost during childcare than men?

I turn to the tests of my hypothesis. I predicted that women should experience greater cost during childcare than men. Regarding the cost that parents experienced with one child (relative to when they had no children), mothers experienced greater physical (Figure 4.2a, chi-squared test, $\chi^2(1)=34.3$, $P<0.001$) and mental cost (chi-squared test, $\chi^2(1)=18.3$, $P<0.001$) than fathers. However, I found no significant sex differences in the perception of time or economic cost (chi-squared tests, $P>0.05$). Regarding the cost that parents experienced with two children (relative to when they had one child), mothers experienced greater physical cost than fathers (Figure 4.2b, chi-squared test, $\chi^2(1)=13.0$, $P<0.01$).

4.4.3. Was the ideal number of children for women smaller than that for men?

I predicted that the ideal number of children for women should be

smaller than that for men. However, my results did not support the prediction. When a couple had no children, mother's ideal number of children was often equal to that of her husband. More specifically, 32 mothers wanted less children than their husbands, 92 wanted the same, and 38 wanted more (Figure 4.3a). I also found no sex differences in the ideal number of children between mothers and their husbands in many cases, when they have/had one child (Figure 4.3b) or two children (Figure 4.3c).

Next, I studied the sex difference in the perception of cost separately for the three types of couples, depending on who wished the larger ideal number of children (i.e., Mother < Father, Mother = Father, or Mother > Father). I found, however, that regardless of the couple type, mothers tended to experience greater physical cost than fathers (but there were some exceptions; see Table 4.2 for details).

4.4.4. Factors affecting the ideal number of children

In Table 4.3, I showed a summary of factors responsible for the ideal number of children. Interaction terms between sex and the other independent variables were not significant (GLMM, $P>0.05$), and therefore I showed only the main effects there. I found that the number of own siblings was the only factor that significantly affected the ideal number of children at the time when couples had no children (Table 4.3a, GLMM, $z=2.20$, $P<0.05$). The estimated positive slope (0.107616) indicated that those who had more siblings wanted more children. For reference, I have plotted the relationship between one's number of siblings and his/her ideal number of children in Figure 4.4. I also found that, when couples have/had one child, their age had significantly negative effect (Table 4.3b, GLMM, $z=-2.04$, $P<0.05$) on their ideal number of children. There existed no significant factors when they have/had two children (Table 4.3c).

4.4.5. Did women have more power to decide whether to have children than men? / Did women desire more for having children than men?

Next, I asked who had more power to decide whether to bear each child, mother or father. I predicted that women should have more power in reproductive decision-making than men, and that it may have caused the fertility decline. However, against my prediction, in many cases, mothers and their husbands answered that they had equal power in deciding to bear the first child (Figure 4.5a) and the second child (Figure 4.5b).

In Table 4.4, I showed the relationship between the type of sex difference in the power to decide whether to have children and the sex difference in the ideal number of children. Regardless of the sex difference in the power, parents often wanted the same number of children (but there were some exceptions; see Table 4.4 for details).

I also asked who desired more for having each child, mother or father. In many cases, mothers and their husbands desired equally for having the first child (Figure 4.6a) and the second child (Figure 4.6b).

Although the sample-size was quite small, I also showed the results for the third child in Figure 4.5c and Figure 4.6c.

4.5. Discussion

In this study, I tested the hypothesis about the sexual conflict over fertility, especially over the number of children, between parents. As I predicted, mothers actually experienced greater cost during childcare than fathers (Figure 4.2). However, in many cases, mothers and their husbands wanted the same number of children (Figure 4.3), they had equal power to decide whether to have children (Figure 4.5), and they desired equally for having children (Figure 4.6). Therefore, among my three predictions, the following two were not supported; that (2) the

ideal number of children for women should be smaller than that for men, and that (3) women should currently have more power in reproductive decision-making than men.

As for the first prediction about the sex difference in the cost during childcare, I specifically investigated major aspects such as time, economic, physical and mental cost. I found that mothers actually experienced greater physical and mental cost of childcare than fathers (Figure 4.2). As a next step, it is necessary to identify what kind of cost is critical for reproductive decision-making for women. Additionally, I should take into account more in detail not only the general physical cost in daily life, but also the highly specific physiological cost to women during pregnancy, childbirth, and breast-feeding.

There are some possible explanations of why my second and third predictions were not supported. I assumed that, under serial monogamy, there should be greater reproductive advantage for men, because the cost of reproduction for men is smaller than that for women. However, contrary to my assumption, there may be little advantage of serial monogamy for men in modern developed societies. For example, men may not have more reproductive advantage by changing their partner than women because of the compensation fee in divorce and the following child-rearing expenses. Also, bad reputations with divorce can be disadvantageous for men and it can suppress the advantage of serial monogamy that men would otherwise enjoy. Those factors may contribute to stabilizing marriage and potentially weaken the conflict over the ideal number of children between parents. Consequently, it could be adaptive for men to desire for the same (i.e., small) number of children as women, even under serial monogamy. Although serial monogamy *potentially* enables individuals to change their partners, it may not *actually* lead to reproductive advantage. Put simply, when having multiple sexual partners is socially banned and/or ecologically

restricted in modern societies, the sex difference in the optimum number of children may disappear (see also Chapter 6).

In the Introduction section, I showed the number of divorces in my study area and argued that it suggests serial monogamy. However, I may have to reconsider this assumption. For example, the age at divorce should also be taken into account, because divorce after couple's reproductive period cannot necessarily yield the advantage of serial monogamy to men. I need to study in more detail how divorce is related to serial monogamy.

I hypothesized that women's having more power in reproductive decision-making should lead to fertility decline. However, this study suggested that it is not necessarily the case; my data showed the possibility that men may adjust their ideal number of children to that of their wives', and therefore that they wanted the same number of children. In this respect, my hypothesis (3) was not supported. I believe that one of the reason for this result was because my hypothesis was too extreme. Looking back the history of modern Japan, patriarchy was the cultural norm before and even after the World War II. Although the new constitution of Japan established in 1946 declared equal rights for men and women, general patterns of men overpowering women have persisted very much in the 1950s and 1960s. Then, the movement for women's liberation started and gradually spread during the 1970s. Therefore, my finding that currently mothers have achieved equal power to their husbands could be enough to cause fertility decline, because it may suggest that women had relatively more power than before.

However, care must be taken in interpreting the result; it is necessary to identify which (i.e. men or women) had adjusted their ideal number to whose. The sexual conflict theory in general predicts that women and men should have different biological optima in their reproductive decision-making. On the other hand, it is also suggested

that once they become a couple, the degree of the sex difference in the ideal number of children may become small (e.g., Mason and Taj, 1987). Mason and Taj (1987) conducted a literature survey and showed that men wanted a larger number of children than women in unmarried samples, but the sex difference was small in married couples. They suggested that married women might suffer from psychological pressure from their husband and tended to follow a men's high ideal. I also speculate that, in marital life, some psychological factors (e.g., affection or obligation to partner) other than biological cost and benefit of reproduction may weaken sexual conflict within a couple, and therefore reproductive interests for one sex tend to agree with those of the other sex. Given the facts that fertility decline occurred in Japan since the 1970s, that the social environment surrounding women changed dramatically, and that my participants in 2013 answered that men and women had equal power in reproductive decision-making, it is much more likely that husbands adjusted their optimal number of children to that of their wives than the opposite scenario. Nevertheless, that does not exclude the possibility that mothers are affected by their husbands' optimal number of children to some extent.

It is important to study the reason of fertility decline from multiple aspects. For example, I have not directly studied the offspring quantity-quality trade-off and its effect on the sexual conflict within a couple in this study. It is possible that changes in socioeconomic factors, such as the upsurge of education cost of children, may have biased the optimal number of children for each sex towards a smaller one, because high parent investment is necessary for each child (cf. Kaplan and Lancaster, 2000, 2003, but see also Goodman et al., 2012).

In this single study, I found no sex differences in the ideal number of children in most cases. Such a trend was also reported in another social survey in Japan (Ministry of Health, Labour and Welfare,

2013). My results show that most of the participants in this study had no sexual conflict over reproductive decision-making within a couple (but see also some methodological limitations discussed later). However, this result does not necessarily mean that there was no sexual conflict over fertility in Japan. For example, I need to explore whether there was sexual conflict in the ideal number of children in Japan from after the World War II to the 1960s by analyzing historical demographic data. In this period, gender equality was gradually recognized but was only partially achieved in Japan. Therefore, it is expected that there existed strong sexual conflict. Notably, the fertility rate dramatically decline around that time (the total fertility rate was 4.54 in 1947, 3.65 in 1950, and 2.00 in 1960, Statistics and Information Department, Minister's Secretariat, Ministry of Health, Labour and Welfare, 2011). Induced abortion was legalized in Japan in 1948, and the movement of family planning as well as the use of contraceptives drew public attention in the 1950s. Those factors may have changed the characteristics of sexual conflict. It is interesting to study the effect of sexual conflict on fertility decline by using historical demographic data, and I leave this as a future study (see also Chapter 6).

I showed that about 60% of mothers and fathers preferred two children before having their first child (Figure 4.1). This result matches the trend known as the two-child family norm (e.g., Carey and Lopreato 1995; Lopreato and Yu, 1988; Morita et al., 2012; Sobotka and Beaujouan, 2014, see also Chapter 3). In previous studies, various factors that can be responsible for this norm were suggested: the trade-off between offspring quality and quantity, the cost-benefit feeling balance of childcare, the decrease in child mortality rates, securing children of both sexes (see also Mason and Taj, 1987 for discussion about the sex preference of children), the effect of cultural norms, and so on. In order to consider the cause of fertility decline, it is important to

study why people wanted two children, because two seems to be too small a number to be explained by fitness maximization (cf. Goodman et al., 2012; Kaplan et al., 1995; Lawson et al., 2012). In this study, I aimed to study the sex difference in the ideal number of children within a couple. As one of the next steps, I also need to investigate why people want such a small number (i.e., two) of children in order to better understand fertility decline.

As factors responsible for the ideal number of children, I found that the number of siblings (Figure 4.4 and Table 4.3a) and the age of parents (Table 4.3b) had significant effects. Although my exploratory study cannot provide a clear evolutionary explanation of them, regarding the effect of the number of siblings, it is possible that the environment where the parents grew up has an influence on their reproductive decision-making. The result suggests the existence of vertical transmission of preference for the ideal number of children. There are some interpretations of the negative effect of age on the ideal number of children. It is reasonable to assume that parents refrained from further childbearing due to some physiological constraints from aging. My analysis revealed that other candidate factors had no significant effects on parents' ideals. As I mentioned above, the distribution of the ideal number of children had a peak at two. It is necessary to explore the factors that led to such a unique distribution.

There exist some limitations in my study. First, and most importantly, participants of the survey were limited to married couples who already had at least one child and had no experience of divorces. Questionnaires to other types of participants, for example, to unmarried couples or those who experienced a divorce will also be important to test the hypotheses about sexual conflict. For example, the experience of divorce itself strongly suggests the existence of sexual conflict within the couple. Second, my study was conducted in an urban area only. In a

previous study in Bolivia, the ideal number of children for women was smaller than that for men in rural areas, but there were no sex differences near towns (McAllister et al., 2012). Third, I asked past thoughts and experiences of parents. However, the accuracy of these answers needs to be considered; they may have answered these questions incorrectly. Fourth, there are other measures to study sexual conflict between parents than the sex difference in the ideal number of children (see also Chapter 6). For example, it has been reported that there is the sexual conflict over contraceptive use (e.g., Borgerhoff Mulder, 2009a; Mace and Colleran, 2009). Fifth, my study was in a cross-sectional design, so I could find no long-term effects of sexual conflict, such as its impact on the number of grandchildren (cf. Pettay et al., 2014). Also, it is desirable to compare demographic situations of at least two time points in order to study fertility decline (i.e., the decrease in birth rate). Sixth, the response rate of my survey was low (i.e., about 55%), so I can improve the procedure. Seventh, my results are based on a study of a Japanese sample at a single site. It is therefore appropriate to interpret my result as the one in modern Japan in an urban area, not as a human universal. Cross-cultural studies would elucidate the impact of sexual conflict on the fertility decline.

In order to clarify complex reproductive decision-making by humans, it is necessary to conduct various studies and collect many pieces of evidence. For example, I analyzed sexual conflict only at a phenotypic level in this study, but its genetic background should also be clarified (cf. Bolund et al., 2013). In my questionnaire survey, I have found no clear evidence of sexual conflict between mother and father over reproductive decision-making within a couple. However, there are some limitations in my study as described above. I believe that further investigation is necessary to draw a more robust conclusion.

Figure legends

Figure 4.1. Ideal number of children for mothers and fathers when they had no children.

Figure 4.2. Sex differences in the perception of cost during childcare.
(a) When parents have/had one child compared with when they had no children, and (b) when parents have/had two children compared with when they had one child.
***: $P<0.001$, **: $P<0.01$ (chi-squared test)

Figure 4.3. Sex differences in the ideal number of children within a couple.
(a) When couples had no children, (b) when they have/had one child, and (c) when they have/had two children.
***: $P<0.001$ (binomial test).

Figure 4.4. The relationship between the number of siblings and the ideal number of children, when couples had no children.
Each lattice point was spread for showing the sample size by using the *jitter* function in R.

Figure 4.5. Who had more power to decide whether to have children, mother or father.
(a) For the first child (6 mothers and 4 fathers answered *Neither*), (b) for the second child (2 mothers and 3 fathers answered *Neither*), and (c) for the third child (3 mothers and 1 father answered *Neither*).
"Mother < Father" includes those who answered *father only* or *both but father more*, "Mother = Father" includes those who answered *both equally*, and "Mother > Father" includes those who answered *mother only* or *both but mother more*.

Figure 4.6. Who desired more for having children, mother or father.
(a) For the first child (12 mothers and 7 fathers answered *Neither*), (b) for the second child (3 mothers and 3 fathers answered *Neither*), and (c) for the third child (2 mothers and 2 fathers answered *Neither*).
I used the same categorization as in Figure 4.5.

Table captions

Table 4.1. Descriptive statistics of participants.

Table 4.2. The relationship between the type of sex difference in the ideal number of children within a couple and what they feel/felt during childcare.
(a) When parents have/had one child, and (b) when they have/had two children.
Each number indicates the number of "yes".

Table 4.3. A summary of factors responsible for the ideal number of children.
(a) When couples had no children, (b) when they have/had one child, and (c) when parents have/had two children.

Table 4.4. The relationship between the type of sex difference in power to decide whether to have children and that in the ideal number of children.
(a) For the first child, (b) for the second child, and (c) for the third child.
See also the legend of Figure 4.5.

Data accessibility

I cannot publicly disclose the raw data that I analyzed in this paper due to the privacy issues of participants. More information is available personally by contacting the author.

Ethics statement

This study was approved by the ethical committee of SOKENDAI (Approval Number: 2013004). Informed consent was obtained from all participants.

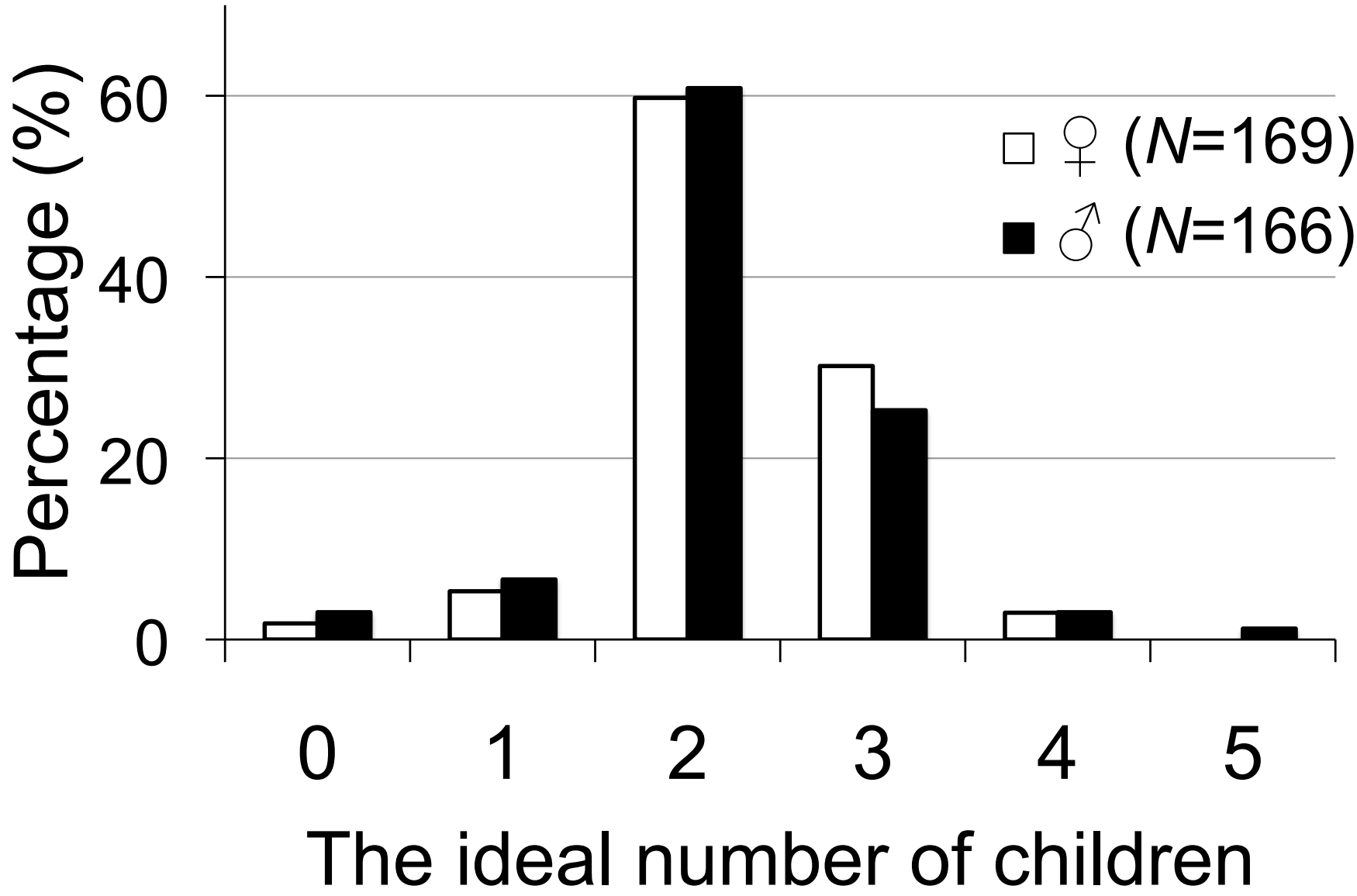

Fig. 4.1 Ideal number of children for mothers and fathers when they had no children

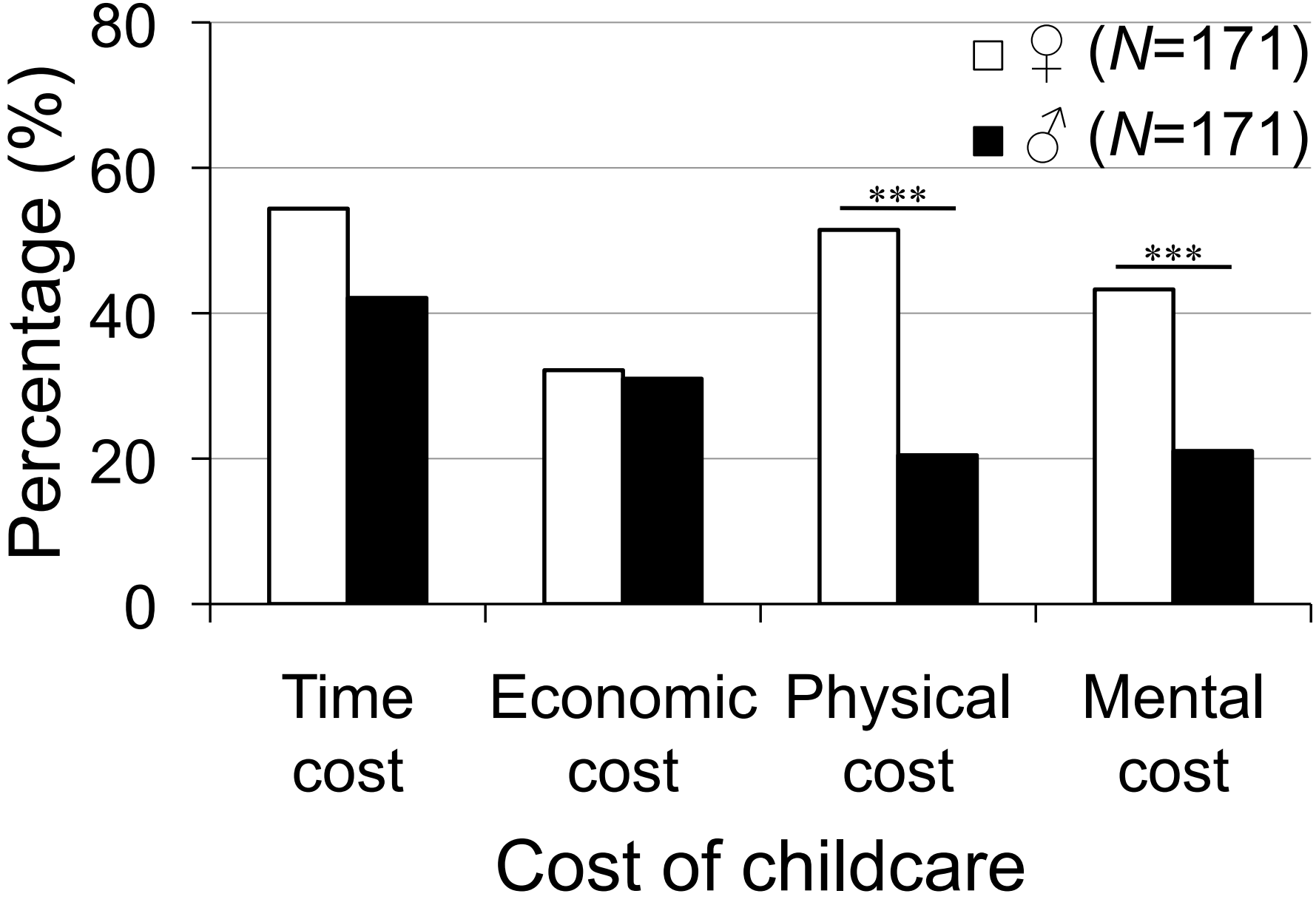

Fig. 4.2 (a) Sex differences in the perception of cost during childcare (when parents have/had one child)

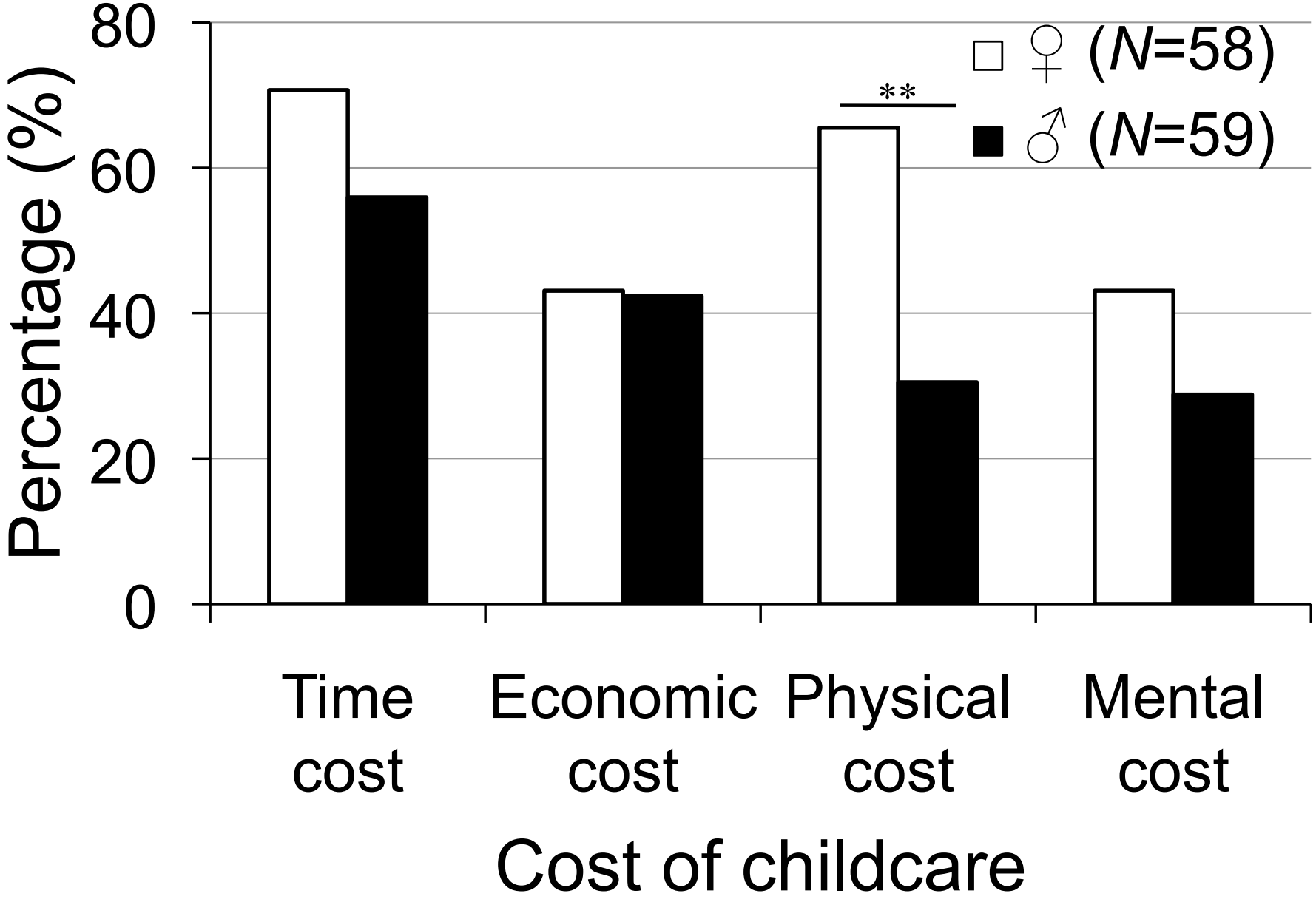

Fig. 4.2 (b) Sex differences in the perception of cost during childcare (when parents have/had two children)

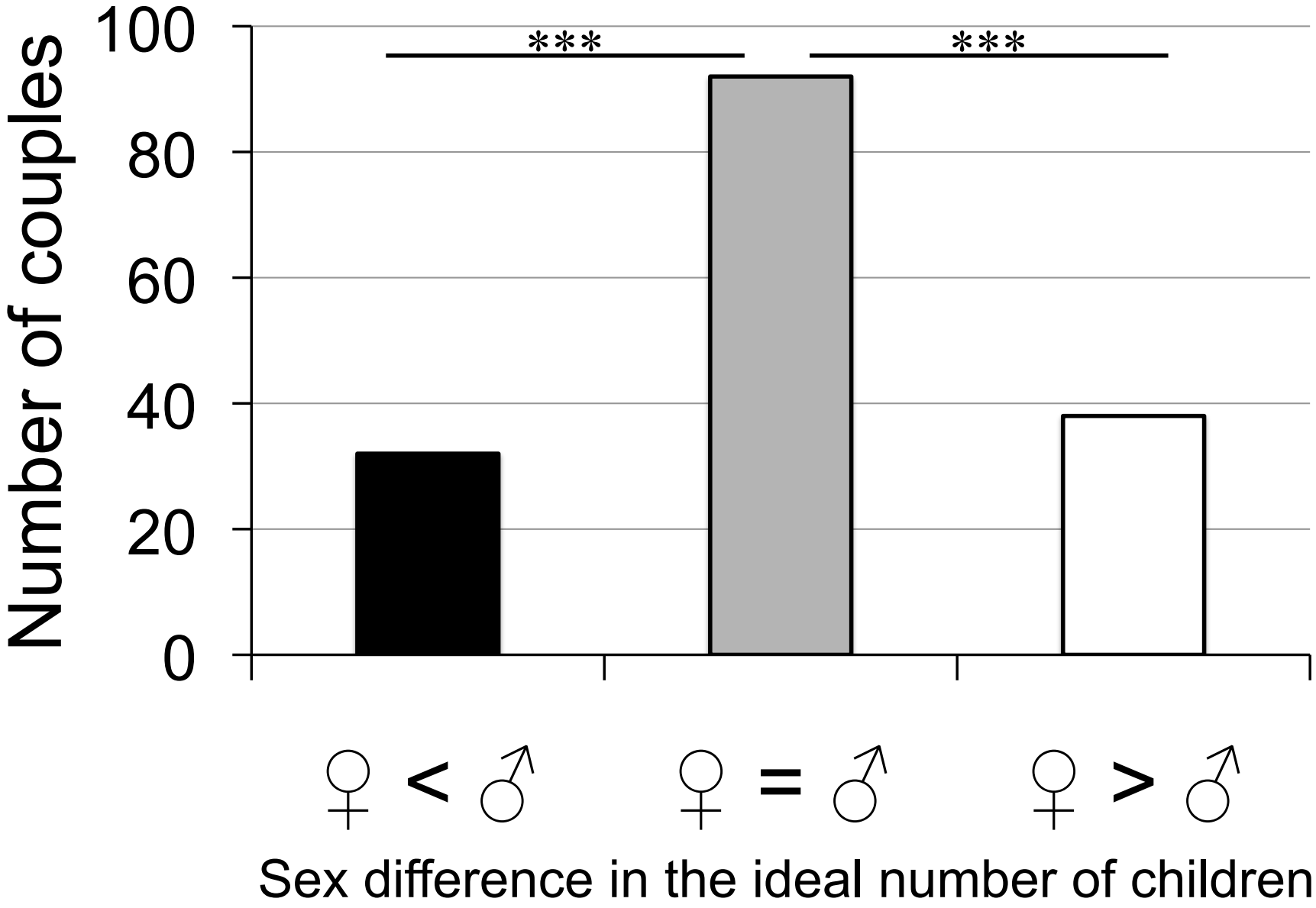

Fig. 4.3 (a) Sex differences in the ideal number of children within a couple (when parents had no children)

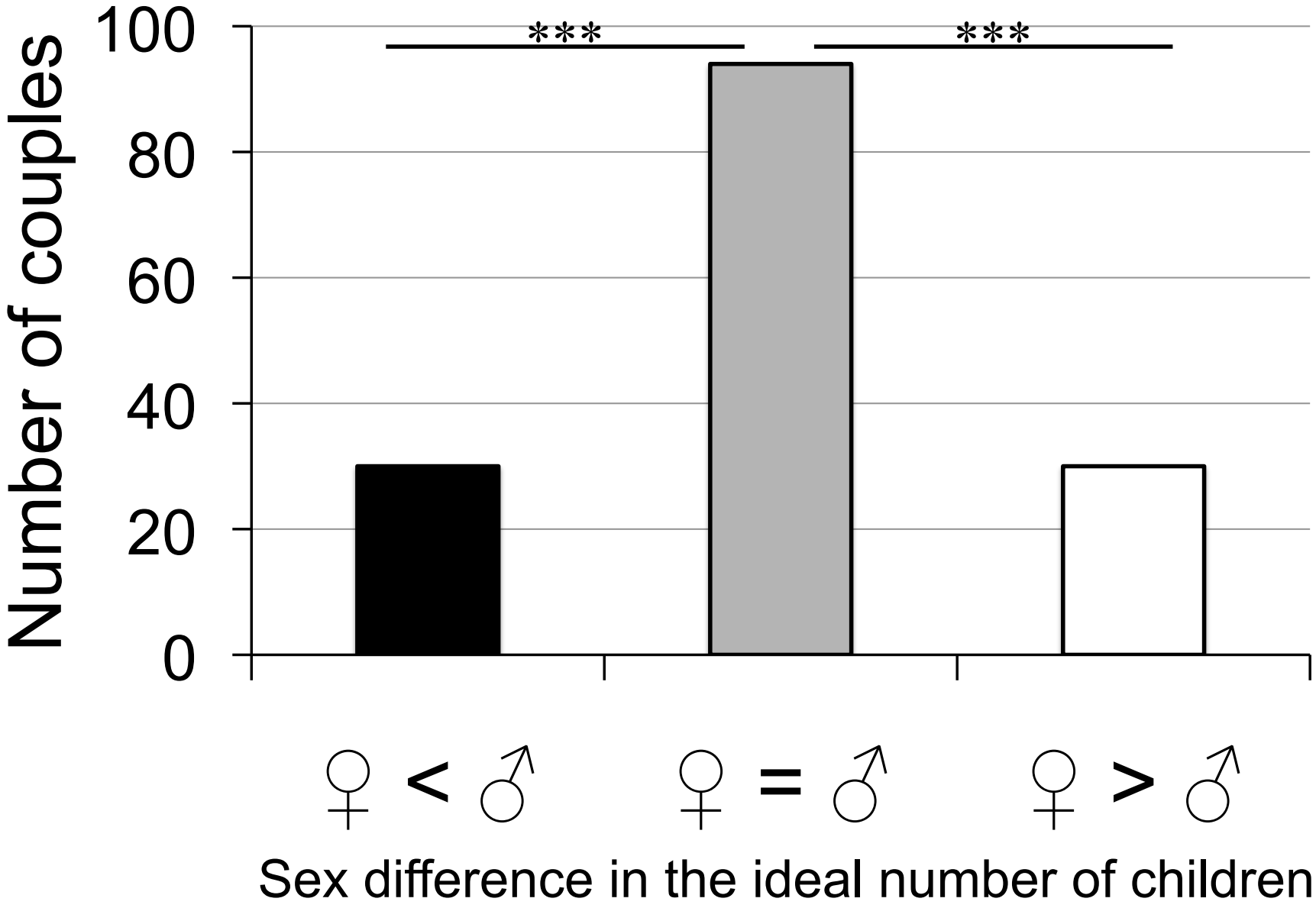

Fig. 4.3 (b) Sex differences in the ideal number of children within a couple (when parents have/had one child)

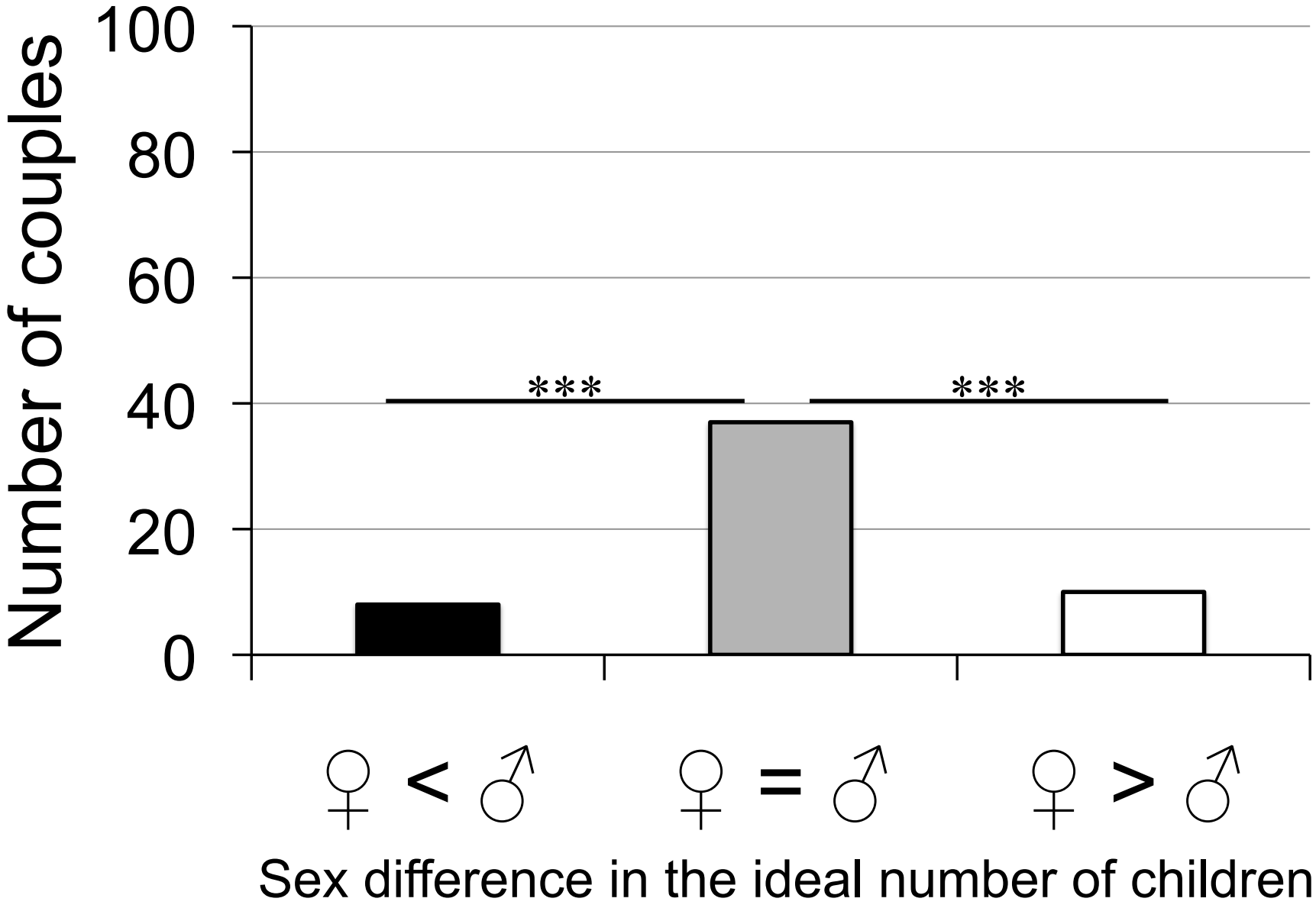

Fig. 4.3 (c) Sex differences in the ideal number of children within a couple (when parents have/had two children)

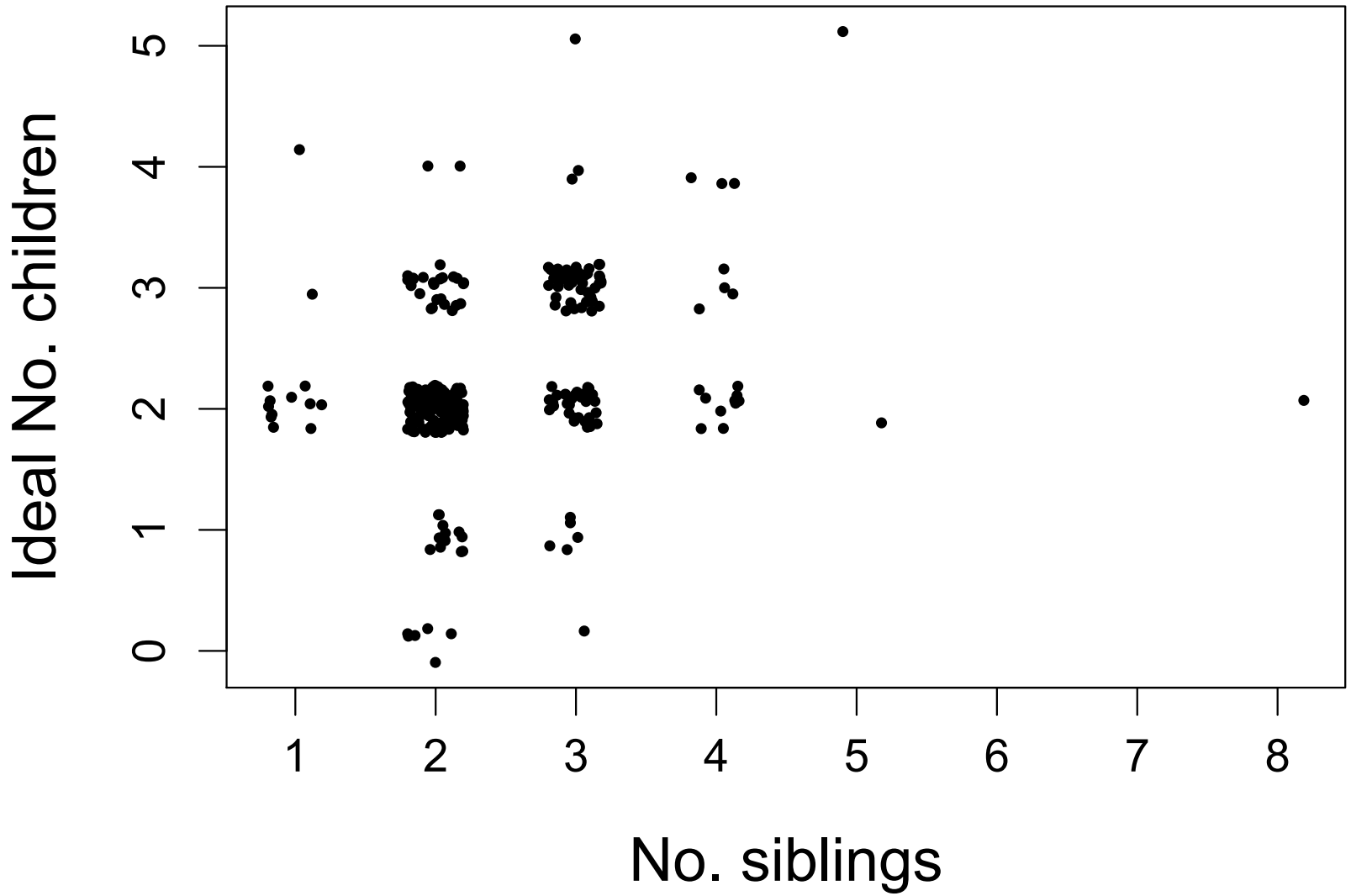

Fig. 4.4 The relationship between the number of siblings and the ideal number of children when couples had no children

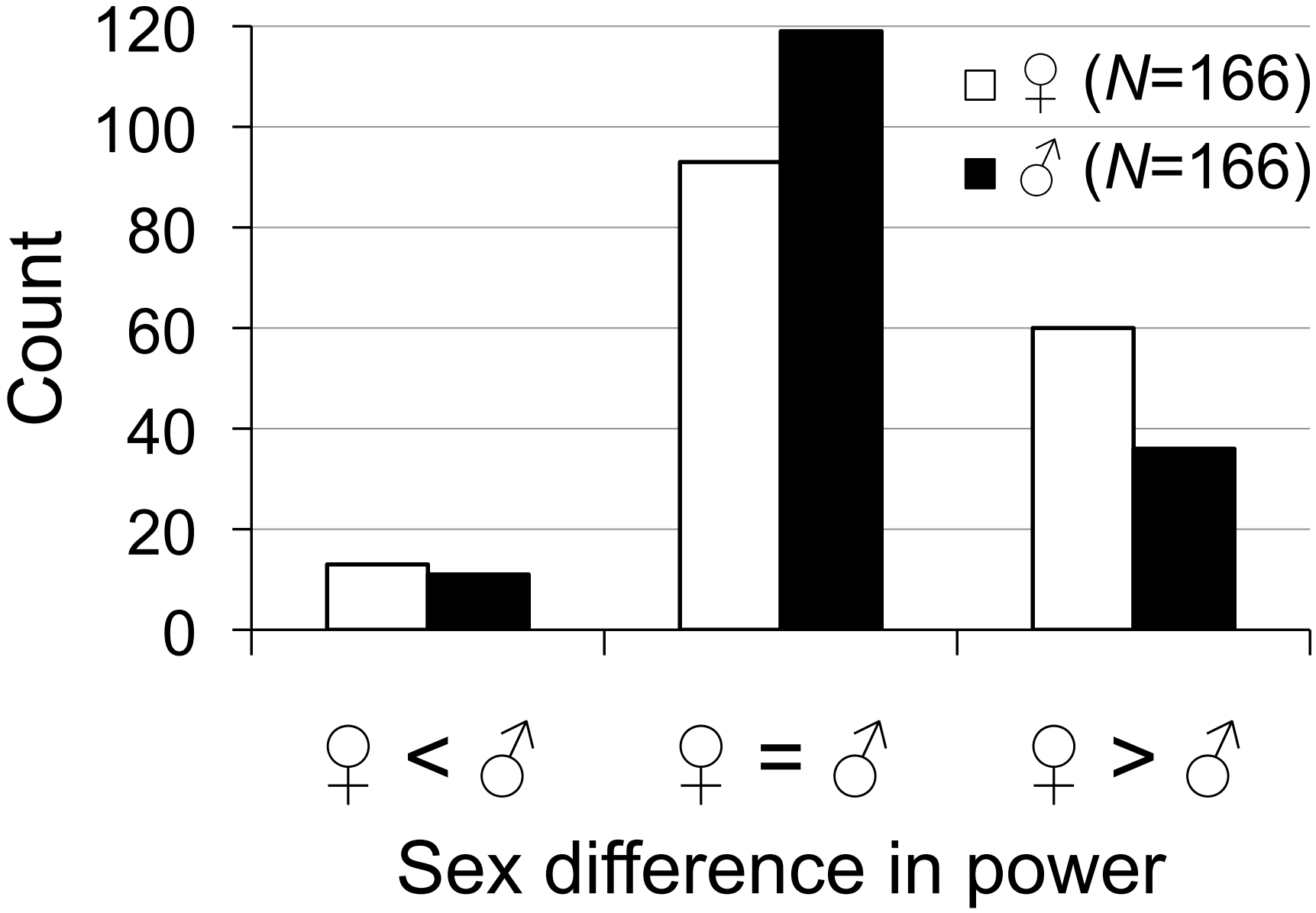

Fig. 4.5 (a) Who had more power to decide whether to have children, mother or father (for the child)

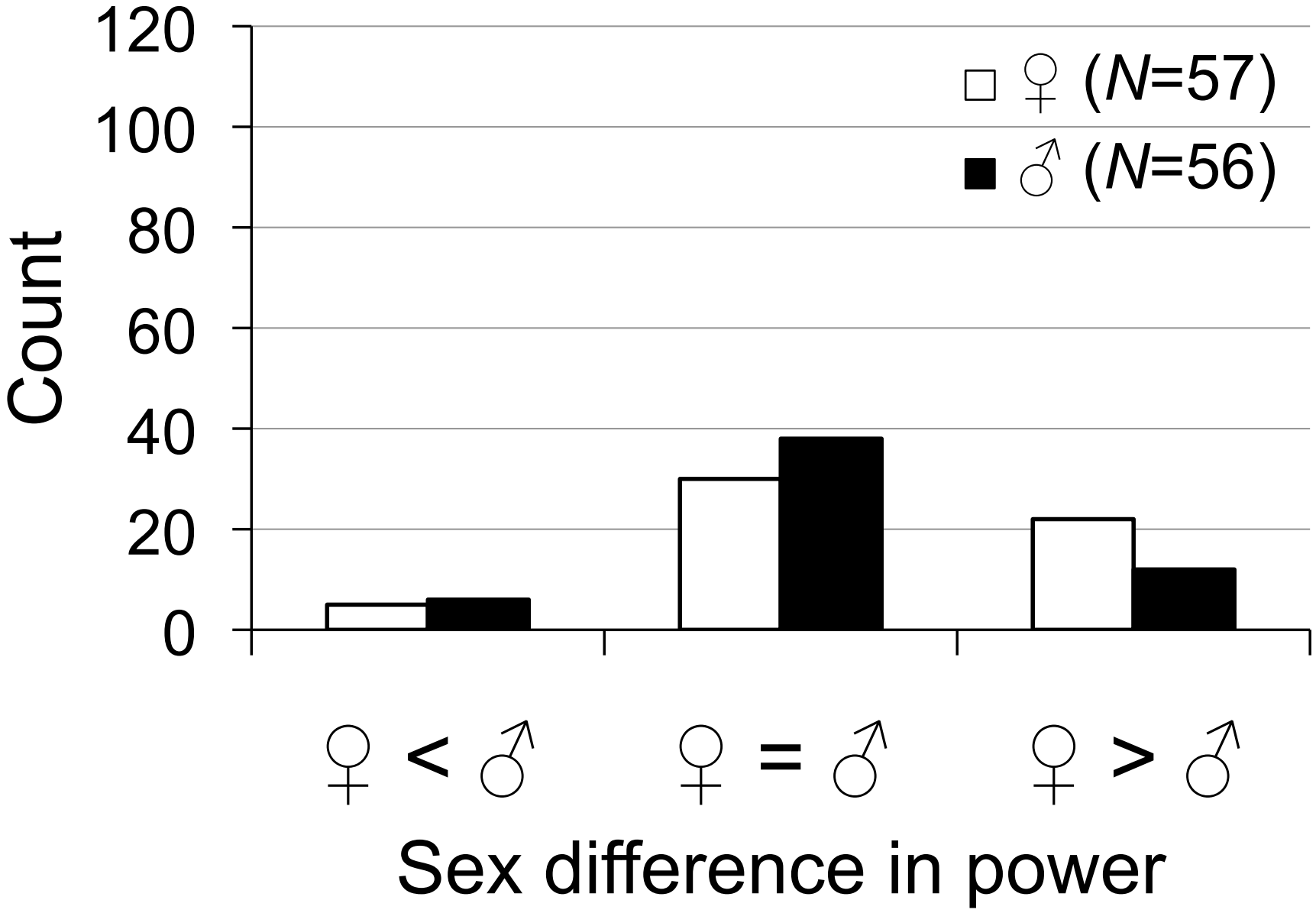

Fig. 4.5 (b) Who had more power to decide whether to have children, mother or father (for the second child)

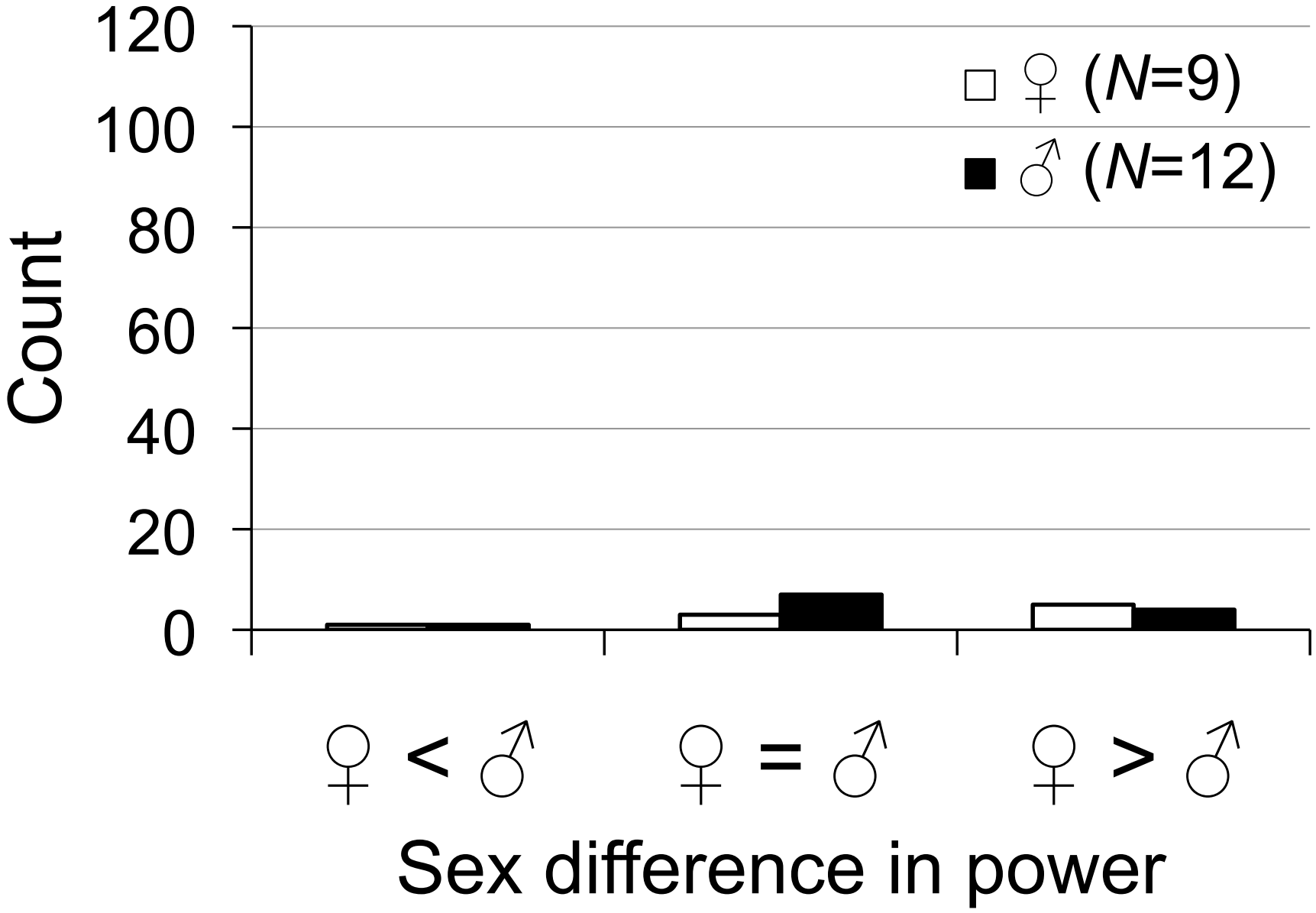

Fig. 4.5 (c) Who had more power to decide whether to have children, mother or father (for the third child)

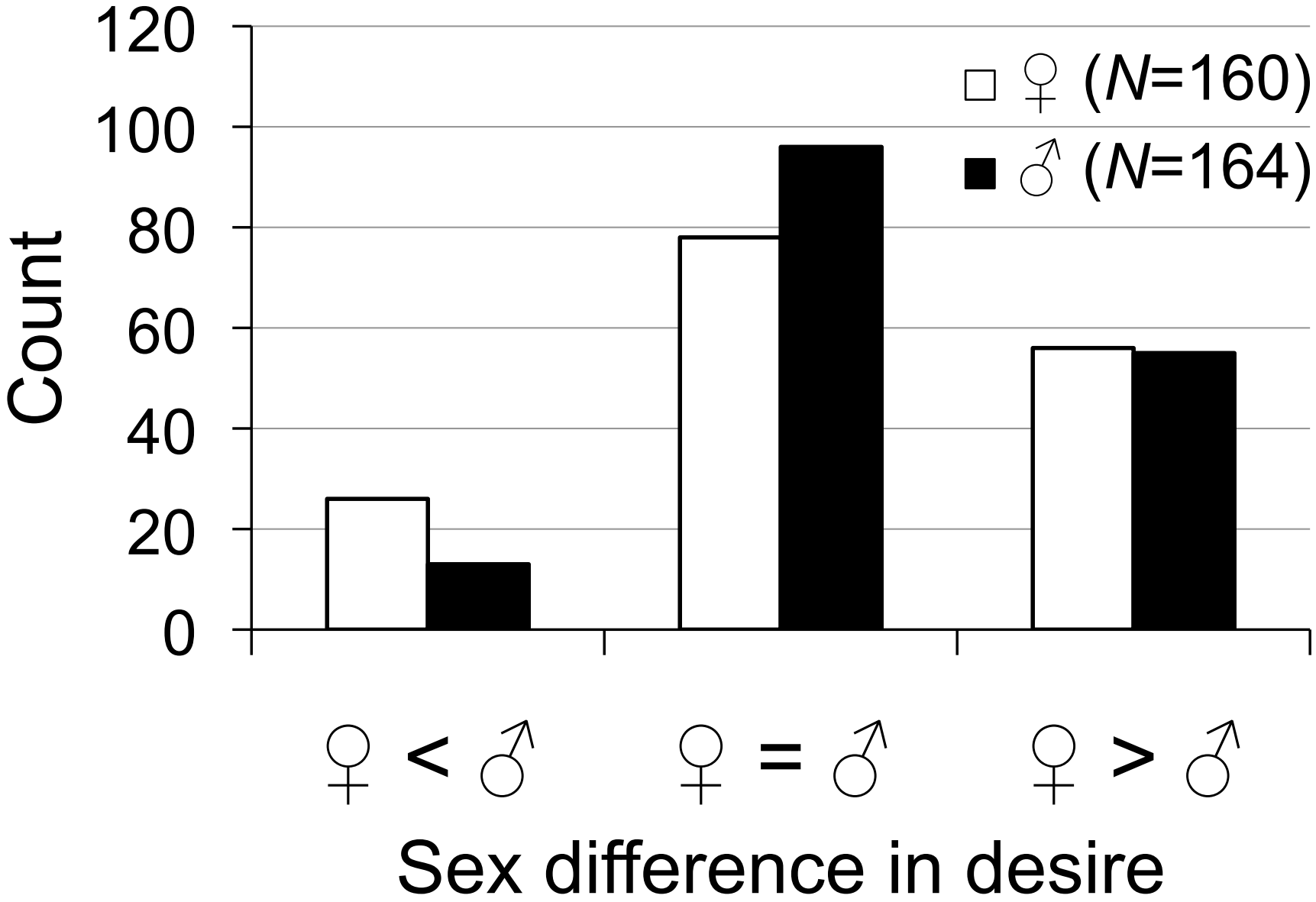

Fig. 4.6 (a) Who desired more for having children, mother or father (for the first child)

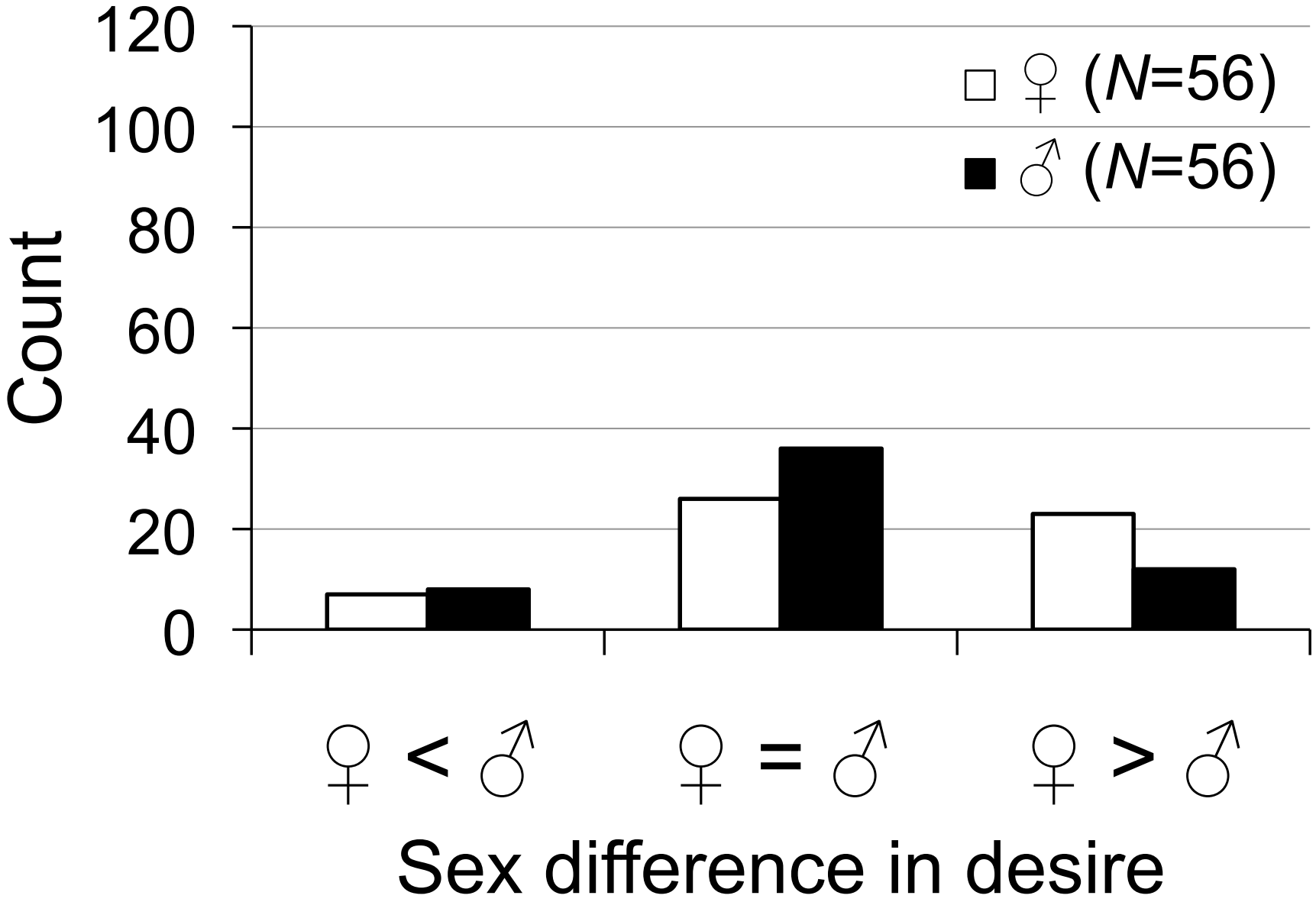

Fig. 4.6 (b) Who desired more for having children, mother or father (for the second child)

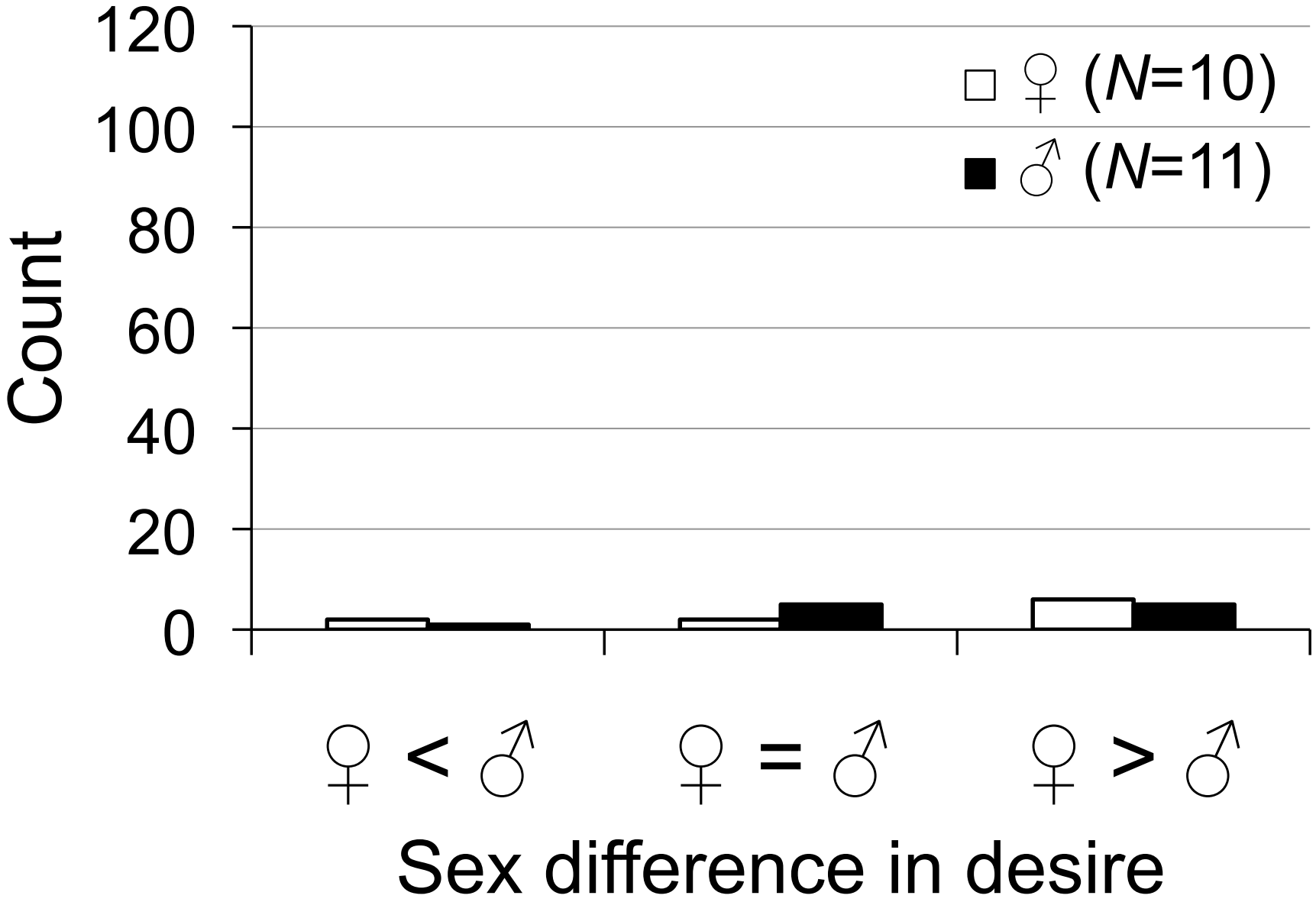

Fig. 4.6 (c) Who desired more for having children, mother or father (for the third child)

Table 4.1 Descriptive statistics of participants

Variable	Number of mothers	Number of fathers
Occupation		
Presence	21	171
Administrative leave	34	0
Absence	118	2
Education level		
Junior high school	1	4
High school	20	30
Junior/vocational college	76	26
University	72	80
Graduate university	4	33
Household income (JPY)[†]		
None	1	
<2 M	2	
≥2 to <4 M	18	
≥4 to <6 M	62	
≥6 to <8 M	36	
≥8 to <10 M	28	
≥10 M to <15 M	18	
≥15 M	1	
NA	7	
Number of siblings		
1	6	8
2	106	90
3	47	60
4	12	13
5	0	2
8	1	0
NA	1	0

[†]When the mother and the father answered different levels within a couple, if the difference was one-level, we showed mother's answer in this table. If the difference was more than one-level, we treated the couples as NA.

Table 4.2 The relationship between the type of sex difference in the ideal number of children within a couple and what they feel/felt during childcare

(a) When parents have/had one child				
Type of sex difference in the ideal number of children	**Time cost**	**Economic cost**	**Physical cost**	**Mental cost**
Mother < Father				
For mothers (N = 30)	18	6	18	17
For fathers (N = 30)	14	10	7	7
Mother = Father				
For mothers (N = 93)	53	32	53	39
For fathers (N = 93)	37	32	24	23
Mother > Father				
For mothers (N = 29)	12	11	11	9
For fathers (N = 29)	15	9	3	4

(b) When parents have/had two children				
Type of sex difference in the ideal number of children	**Time cost**	**Economic cost**	**Physical cost**	**Mental cost**
Mother < Father				
For mothers (N = 8)	6	4	4	4
For fathers (N = 8)	2	2	4	2
Mother = Father				
For mothers (N = 37)	26	16	27	16
For fathers (N = 37)	22	20	11	12
Mother > Father				
For mothers (N = 10)	7	4	6	4
For fathers (N = 10)	7	3	2	3

Table 4.3 A summary of factors responsible for the ideal number of children

(a) Dependent variable was the ideal number of children when couples had no children

(unit = person, distribution = 0: 7, 1: 17, 2: 186, 3: 76, 4: 8, and 5: 2)

Independent variable	Coefficient	S.E.	*z*	*P*
Sex (0: woman, 1: men)	-0.026493	0.079330	-0.33396	0.7380
Age (years old)	-0.007766	0.008122	-0.95745	0.3380
Number of siblings (person)	0.107616	0.048807	2.20492	0.0275
Education level (continuous)	0.013988	0.044807	0.31218	0.7750
Household income (continuous)	0.010141	0.035394	0.28651	0.7740
Presence of housewife (0: absence, 1: presence)	0.001639	0.091698	0.01788	0.9860

The largest *r* was -0.3325 between household income and the presence of housewife.

The residual deviance was 76.38 on 288 *df*.

(b) The ideal number of children when parents have/had one child

(unit = person, distribution = 0: 32, 1: 183, 2: 59, 3: 3, and 4: 1)

Independent variable	Coefficient	S.E.	*z*	*P*
Sex (0: woman, 1: men)	-0.041815	0.12267	-0.34086	0.7330
Age (years old)	-0.024899	0.01221	-2.03994	0.0414
Number of siblings (person)	0.051531	0.07106	0.72521	0.4680
Education level (continuous)	-0.046889	0.06510	-0.72023	0.4710
Household income (continuous)	0.059243	0.05174	1.14507	0.2520
Presence of house wife (0: absence, 1: presence)	-0.037861	0.13153	-0.28785	0.7730
Time cost (0: no, 1: yes)	0.042686	0.12176	0.35058	0.7260
Economic cost (0: no, 1: yes)	0.009494	0.13190	0.07198	0.9430
Physical cost (0: no, 1: yes)	-0.123847	0.13448	-0.92096	0.3570
Mental cost (0: no, 1: yes)	-0.203345	0.14391	-1.41300	0.1580

The largest *r* was 0.3878 between the perception of physical cost and mental cost.

The residual deviance was 107.1 on 266 *df*.

(c) The ideal number of children when parents have/had two children

(unit = person, distribution = 0: 66 and 1: 36)

Independent variable	Coefficient	S.E.	*z*	*P*
Sex (0: woman, 1: men)	-0.24953	0.37932	-0.6578	0.511
Age (years old)	0.03535	0.03889	0.9090	0.363
Number of siblings (person)	0.22793	0.18029	1.2642	0.206
Education level (continuous)	-0.19493	0.20724	-0.9406	0.347

Table 4.3 continued

Household income (continuous)	-0.06715	0.14785	-0.4542	0.650
Presence of house wife (0: absence, 1: presence)	0.54010	0.47063	1.1476	0.251
Time cost (0: no, 1: yes)	-0.47553	0.41066	-1.1580	0.247
Economic cost (0: no, 1: yes)	0.20891	0.37397	0.5586	0.576
Physical cost (0: no, 1: yes)	0.47391	0.41184	1.1507	0.250
Mental cost (0: no, 1: yes)	-0.49914	0.46305	-1.0779	0.281

The largest *r* was 0.4708 between the perception of time cost and mental cost.

The residual deviance was 66.51 on 90 *df*.

Table 4.4 The relationship between the type of sex difference in power to decide whether to have children and that in the ideal number of children

(a) For having the first child			
Type of sex difference in power to decide whether to have children	**Type of sex difference in the ideal number of children**		
	Mother < Father	**Mother = Father**	**Mother > Father**
Mother < Father			
For mothers	3	9	1
For fathers	3	7	1
Mother = Father			
For mothers	15	53	16
For fathers	20	72	20
Mother > Father			
For mothers	12	25	21
For fathers	7	11	16

(b) For having the second child			
Type of sex difference in power to decide whether to have children	**Type of sex difference in the ideal number of children**		
	Mother < Father	**Mother = Father**	**Mother > Father**
Mother < Father			
For mothers	2	2	1
For fathers	3	3	0
Mother = Father			
For mothers	6	12	5
For fathers	7	17	7
Mother > Father			
For mothers	4	10	8
For fathers	2	4	6

(c) For having the third child			
Type of sex difference in power to decide whether to have children	**Type of sex difference in the ideal number of children**		
	Mother < Father	**Mother = Father**	**Mother > Father**
Mother < Father			
For mothers	0	0	1
For fathers	0	0	1
Mother = Father			
For mothers	0	2	0
For fathers	1	4	0
Mother > Father			

Table 4.4 continued

For mothers	0	3	1
For fathers	0	2	2

Chapter 5

General title

Wealth, peer competition, self-enhancement, and fertility decline: a mathematical model

More specific title

Maximization of *"Happiness"* (= biological fitness and self-enhancement): a mathematical model of fertility decline

5.1. Abstract

For understanding fertility decline, I need to explain how parents allocate their wealth to offspring/themselves and what environmental conditions lead to the decrease in fertility. In this study, I analyze a wealth-fertility relationship from the perspectives of peer competition among offspring and psychological satisfaction through self-enhancement. In urban societies with competitive labor and mating markets, parental cost for childcare should be larger and fertility should consequently be lower than that in rural societies. Some examples of self-enhancement are dressing in designer clothing, acquiring luxury cars, and enjoying leisure activities. These may be extreme examples, but it is reasonable to assume that, in a modern life style, people face a number of attractive options that do not directly enhance their reproductive success. I assume that parents try to maximize *"Happiness"*, which is defined as the product of biological fitness and self-enhancement. Note that this assumption deviates from a purely evolutionary model. My mathematical models predict that a high investment in child quality and self-enhancement reduce fertility. These results would match the situations observed in modern low-fertility societies. In this paper, I compare the results from two different models.

5.2. Introduction

5.2.1. Wealth-fertility relationship

As I wrote in Chapter 2, a general feature of fertility decline is that it is often associated with a lack of a positive relationship between wealth (i.e., economic resources) and the number of offspring, particularly in modern developed societies (e.g., Borgerhoff Mulder, 1998; Hill and Reeve, 2005; Kaplan and Lancaster, 2000, 2003). Such a non-positive (i.e., negative or null) relationship has been viewed as a great challenge to evolutionary understanding of human behavior (Vining, 1986, see also Chapter 2 and Chapter 3 for details).

Mace (2008) provided an insightful perspective about the wealth-fertility relationship. She suggested that even if there exists a negative or null relationship between wealth and fertility *among* sub-populations, the relationship can be positive *within* a sub-population (see also Mace, 2007 for a similar perspective). Here, the difference in wealth among sub-populations means a rural-urban gradient; that is, people in rural societies have lower wealth and those in urban societies have higher wealth. Also, socioeconomic environments should be quite different among sub-populations. In urban societies with a skills-based competitive labor market and a subsequent competitive mating market, parental cost for childcare should be larger and fertility should consequently be lower than that in rural societies (e.g., Kaplan and Lancaster, 2000, 2003, see also Chapter 6). As an empirical example, Alvergne and Lummaa (2014) confirmed these two aspects of the wealth-fertility relationship in Mongolia. They showed that individuals in urban areas had a smaller number of children than those in rural areas and that wealthier individuals have a larger number of children than the poorer within a sub-population.

Based on these points above, Mace (2008) concluded that

"transfers of resources from parents to offspring are key to understanding human life-history evolution" (p. 765). She also suggested that sibling competition for family resources including inherited wealth generated by their parents should have a large impact on parents' reproductive strategies. Thomas et al. (2015) studied sibling competition for family wealth. They showed that, under low infant mortality rates, high levels of sibling competition over family resources should increase optimal birth intervals and would decrease family size. Hill and Reeve (2005) theoretically studied the competition for inherited wealth. They showed that having a small number of children with affluent resources should be evolutionarily adaptive for offspring lineages in a long-term view, when offspring inherited family resources. However, this model assumed that highly fertile lineages ultimately survive less well and that the poor survival of such lineages happens because low-fecundity lineages oust their resources. This assumption may be considered an unrealistic set of assumptions for human societies experiencing increased wealth. At least, there is no empirical evidence that actually confirmed this assumption.

To list other examples of theoretical studies about the wealth-fertility relationship, Mace (1996) showed that household wealth should be a notable factor for parents' decision-making concerning having another child, especially under the high cost of marrying off their children. Mace (1998) predicted that wealth for childcare should be significant for family size. She discussed its effect on fertility decline and suggested that an attitude towards having a smaller number of highly educated children should decrease the family size.

5.2.2. Peer competition among offspring and self-enhancement

In this chapter, I study fertility decline from the perspective of wealth-fertility relationship by using a mathematical model. To my

knowledge, theoretical evidence of the effect of wealth on fertility decline is still very limited. In particular, I shed light on effects of peer competition among offspring and self-enhancement. These two aspects should be important in studying the wealth-fertility relationship. With regard to the peer competition among children, it is well discussed that lower quality individuals tend to lose in peer competition in labor and mating markets in modern developed societies and that just maximizing the number of children should not be optimum in terms of fitness maximization, because of a trade-off between offspring quantity and quality (e.g., Borgerhoff Mulder, 1998; Kaplan et al., 1995). Although some empirical studies showed that a smaller number of children did not lead to a higher long-term fitness (e.g., Goodman et al., 2012; Kaplan et al., 1995; see also Jones and Bird, 2014; Lawson et al., 2012 and the Discussion section), it is expected that in modern developed societies with a skills-based competitive environment, lower quality individuals, such as ones who earn a lower income or who have a lower education level, should have lower reproductive success. It is therefore expected that parents should have a large amount of effort for childcare and would aim to have a small number of children (e.g., Kaplan 1996; Kaplan and Lancaster, 2000, 2003; Kaplan et al., 1995; Snopkowski and Kaplan, 2014, see also Chapter 6).

I also take into account the self-enhancement that should affect parents' resource allocation and decision-making on family size. Some examples of self-enhancement are dressing in designer clothing, wearing expensive jewelry, acquiring luxury cars, and enjoying leisure activities. These may be somewhat extreme examples, but it is reasonable to assume that, in a modern life style, people face a number of attractive options for self-enhancement that (seemingly) do not directly enhance their reproductive success (see also the Discussion section). Such self-enhancement emerged especially in modern developed societies. I

think that people are currently facing a trade-off between investment in offspring and in self-enhancement (i.e., investment in themselves). Boyd and Richerson (1985) paid attention to this point. They said that *"people may also feel that children conflict with the goal of maintaining an appropriate life-style, the right kind of house, car, leisure time activities, and so forth"* (Boyd and Richerson, 1985, p. 200, see also Richerson and Boyd, 2005; Kaplan and Lancaster, 2000; Kaplan et al., 2002 for similar arguments). In this sense, I admit that the model that I will construct deviates from a purely evolutionary one; I assume that parents maximize something else than the ultimate number of surviving gene copies in future generations. Moreover, self-enhancement may be understood as one of the norms of culturally transmitted prestige-seeking behavior (e.g., Boyd and Richerson, 1985; Ihara, 2008; Richerson and Boyd, 2005), whether or not the prestige ultimately translates into higher reproductive success.

By focusing on these factors, I study resource allocation strategies on reproduction. I analyze environmental conditions that lead to fertility decline. I focus not only on biological fitness, but also on some cultural and psychological aspects that can make parents' decision deviate from purely evolutionary optima. In particular, I assume that parents try to maximize *"Happiness"*, which is defined as the product of biological fitness and self-enhancement (see also Clark et al., 2008 for other discussions about happiness).

5.3. Model and Results

5.3.1. Basic model

I assume that parents face a resource (i.e., wealth) allocation problem. I suppose that parents of each family have resource W and that they decide the number of children, n (note that n should be an integer in reality, but I treat it as a real number in my model), and the amount

parental investment for child survival, s (*per child*). Therefore, the resource constraint is

$$W = ns.$$

Parents try to maximize their reproductive fitness, H. I assume that a child that received the parental investment s survives with probability,

$$S(s) = \frac{\left(\frac{s}{s_0}\right)^2}{1+\left(\frac{s}{s_0}\right)^2},$$

where S is the survival function (a sigmoid function). s_0 is equal to the amount of investment with which the survival probability becomes 0.5. A larger value of s_0 means a worse environment for child survival. Parents need to invest a larger amount of effort to keep their children alive in an environment with a larger s_0. I graphically show the function S in Figure 5.1. The objective function to be maximized is

$$H = n \cdot S(s).$$

To solve this maximization problem, I substitute

$$s = \frac{W}{n}$$

in H and calculate a value of n that satisfies

$$\frac{dH}{dn} = 0.$$

The maximization problem has the solution

$$n^* = \frac{W}{s_0}, \qquad s^* = s_0,$$

and the maximum reproductive fitness is given as

$$H^* = \frac{W}{2s_0}.$$

5.3.2. Multiplicative model with a relative benefit of self-enhancement

5.3.2.1. Assumptions

I modify the basic model in two ways. Firstly, I introduce peer competition among children. More specifically, I assume that an individual with a higher quality or a higher socioeconomic status, for example, should be more successful in competitive labor and mating markets. The parental investment for child quality is denoted by q (*per child*), and I assume that it is distinct from the investment for child survival, s.

Secondly, I assume that parents can invest their resource a for their self-enhancement, such as their leisure activities. I assume that, through self-enhancement, parents gain a psychological (but not necessarily reproductive) benefit.

Therefore, the new resource constraint for parents is

$$W = n(s+q) + a.$$

I graphically show the new constraint in Figure 5.2.

Here, I assume a multiplicative model. That is, parents try to maximize the product of their biological fitness through offspring and the amount of psychological satisfaction through self-enhancement. This product is denoted by H again and called parents' *Happiness* in the following. It is given by

$$H = n \cdot S(s) \cdot Q(q) \cdot A(a),$$

where S is the survival function (Figure 5.1). Q is proportional to the probability of gaining a mating partner, which is determined by child quality, q, such as his/her socioeconomic status. I assume that it is given by

$$Q(q) = \left(\frac{q}{\bar{q}}\right)^{\alpha},$$

where $\bar{q}$ is the population average level of q. The parameter $0<\alpha<1$ measures the importance of child quality in a mating market (Figure 5.3).

The function A represents psychological satisfaction through self-enhancement. In this section, I assume that the magnitude of one's subjective psychological satisfaction is *relative* to others' and assume

$$A_{relative}(a) = \left(\frac{a}{\bar{a}}\right)^{\beta},$$

where $\bar{a}$ is the population average level of a. The parameter $\beta>0$ measures the importance of self-enhancement (Figure 5.4).

5.3.2.2. Analysis of Evolutionarily Stable Strategy (ESS)

Let me assume that strategy n^*, s^*, q^*, and a^* is an ESS, and suppose that this strategy dominates the population. Under this assumption, *Happiness* of a mutant whose strategy is n, s, q, and a can be calculated as

$$H(n,\ s,\ q,\ a) = n \cdot \frac{\left(\frac{s}{s_0}\right)^2}{1+\left(\frac{s}{s_0}\right)^2} \cdot \left(\frac{q}{q^*}\right)^{\alpha} \cdot \left(\frac{a}{a^*}\right)^{\beta}.$$

The values of (n, s, q, a) that maximize H can be derived by using the method of Lagrange multipliers. Here, I can equate these values to (n^*, s^*, q^*, a^*) because I assumed that (n^*, s^*, q^*, a^*) is an ESS. In this way, the evolutionary stable resource allocation can be derived. As a result, the ESS of the multiplicative model with a relative benefit of self-enhancement is

$$n^* = \frac{W}{s_0}\frac{(1-\alpha)^{\frac{3}{2}}}{(1+\alpha)^{\frac{1}{2}}}\frac{1}{1+\beta}, \qquad s^* = s_0\frac{(1+\alpha)^{\frac{1}{2}}}{(1-\alpha)^{\frac{1}{2}}}, \qquad q^* = s_0\frac{\alpha(1+\alpha)^{\frac{1}{2}}}{(1-\alpha)^{\frac{3}{2}}}, \qquad a^* = W\frac{\beta}{1+\beta},$$

and the level of *Happiness* at that ESS is calculated as

$$H^* = \frac{W}{2s_0}\frac{(1-\alpha)^{\frac{3}{2}}(1+\alpha)^{\frac{1}{2}}}{1+\beta}.$$

The results indicate the following things: (1) that a larger amount

of parental resource (i.e., a larger W) leads to a larger number of children (i.e., a larger n^*) and a larger amount of investment in self-enhancement (i.e., a larger a^*), (2) that a worse environment for child survival (i.e., a larger s_0) reduces the number of children, (3) that an increase in the importance of child quality (i.e., a larger α) reduces the number of children (Figure 5.5), and (4) that an increase in the importance of self-enhancement (i.e., a larger β) reduces the number of children (Figure 5.6). I show a summary of results from the model in Table 5.1.

I also show the relationship between the importance of child quality (α) and the level of *Happiness* at ESS (H^*) in the relative benefit model in Figure 5.7, and the relationship between the importance of self-enhancement (β) and H^* in Figure 5.8.

5.3.3. Multiplicative model with an absolute benefit of self-enhancement

5.3.3.1. Assumptions

I slightly change the previous assumption and assume instead that the psychological benefit via self-enhancement is not relative but absolute. In particular, I assume that the function A is given by

$$A_{absolute}(a) = \left(\frac{a}{a_0}\right)^{\beta},$$

where a_0 is the baseline investment to self-enhancement that yields the satisfaction of $A_{absolute}(a_0) = 1$.

5.3.3.2. ESS analysis

By using the same approach in 5.3.2.2, I perform the ESS analysis. The ESS of the multiplicative model with an absolute benefit of self-enhancement is

$$n^* = \frac{W}{s_0}\frac{(1-\alpha)^{\frac{3}{2}}}{(1+\alpha)^{\frac{1}{2}}}\frac{1}{1+\beta}, \qquad s^* = s_0\frac{(1+\alpha)^{\frac{1}{2}}}{(1-\alpha)^{\frac{1}{2}}}, \qquad q^* = s_0\frac{\alpha(1+\alpha)^{\frac{1}{2}}}{(1-\alpha)^{\frac{3}{2}}}, \qquad a^* = W\frac{\beta}{1+\beta},$$

and the level of *Happiness* attained at the ESS is

$$H^* = \frac{W}{2s_0}\frac{(1-\alpha)^{\frac{3}{2}}(1+\alpha)^{\frac{1}{2}}}{1+\beta}\left(\frac{W}{a_0}\frac{\beta}{1+\beta}\right)^{\beta}.$$

Interestingly, the results of n^*, s^*, q^*, and a^* are the same as those in the relative benefit model (see 5.3.2.2).

5.4. Discussion

In this study, I proposed a mathematical model of *Happiness* and assumed that parents try to maximize the product of biological fitness and the amount of psychological satisfaction through self-enhancement. This model deviates from a purely evolutionary one because of this assumption. However, I believe that self-enhancement is an important aspect to understand human life-history strategies and reproductive decision-making regarding family size, even if it does not directly enhance one's reproductive success.

As a result, I have found that an increase in the importance of self-enhancement (β) reduces the number of children (n) (Figure 5.6). This is not a surprising result according to my model assumptions, but I have provided a piece of theoretical evidence regarding the effect of self-enhancement, that would be related to prestige-seeking behavior and cultural evolution, on fertility decline. My model assumed that one's psychological satisfaction through self-enhancement did not have any links to his/her biological fitness in a current environment. On the other hand, seeking self-enhancement might be adaptive in an ancestral environment. One's achieving higher psychological satisfaction through self-enhancement might mean that the individual had a higher status and an advantage in gaining a mating partner. In this sense, psychological

satisfaction via self-enhancement could be linked to one's attractiveness in our ancestral environment. To complete this argument, I need to study the next questions: *What is the evolutionary basis of psychological satisfaction through self-enhancement in an ancestral environment where human psychological mechanisms evolved and where there were much fewer options for self-enhancement?* (see also Chapter 6).

I have also found that an increase in the importance of child quality (α) reduces the number of children (n) (Figure 5.5), as well as the importance of self-enhancement (β) does. These results match the situation observed in modern low-fertility societies. In such societies, there are many options for self-enhancement, which conflict with options for enhancing one's reproductive success. There also exist higher levels of peer competition in labor and mating markets among children when they grow up.

My model predicted that an increase in the importance of child quality (a larger α) leads to a larger amount of investment for child quality (a larger q), but it also leads to a larger amount of investment for child survival (a larger s) (Table 5.1). In the same manner, I found that a worse environment for child survival (a larger s_0) leads to a larger amount of investment for child survival (a larger s), but it also leads to a larger amount of investment for child quality (a larger q) (Table 5.1). This is an interesting point in my model. One possible explanation is that child survival and child quality are merely two aspects of the same value of having children. It is expected that a greater importance of investment for child survival is equal to that for child quality simultaneously, and *vice versa*.

In their theoretical model, Hill and Reeve (2005) showed that if there is *actually* a severe competition for the survival of offspring's lineage (they assumed that its strength is given by their "resource snowballing parameter", y, which is conceptually close to my parameter

α), fertility decline can occur. However, here I claim that even if the strong competition is *not present*, fertility decline can occur as long as parents (mistakenly) perceive that the competition is strong enough. This is because our ancestral environment must have shaped the evolution of our psychological module that chooses the optimal level of the number of offspring (n) depending on the perceived level of competition strength (α) in their environment. This approach is called "evolutionary psychology" (e.g., Barkow et al., 1992). In evolutionary psychology, researchers focus on the adaptation to the ancestral environment (EEA: Environment of Evolutionary Adaptation). They are mainly interested not in behavior observed in the current environment but in evolved mechanisms generally underlying each behavior (see also Chapter 6). This approach can be the same as McNamara and Houston (2006)'s argument that *"natural selection acts on strategies rather than resulting outcomes"* (p. 62). There should exist ecological differences between the EEA and the current environment, so evolved psychological mechanisms in humans that were adaptive in the past may not work adaptively in the current environment. Because of the mismatch between these environments, maladaptive outcomes at a phenotypic level can be observed in a current environment.

In modern developed and low-fertility societies, it could be the case that parents mistakenly estimate the cost of childcare as too high, and that they decide to bear a small number of children accordingly. That is, even if the amount of investment is *enough*, they will not assess so. (Here, *enough* means "enough for genetic success that maximizes one's reproductive fitness, not enough for cultural success that maximizes one's psychological satisfaction"). In the EEA, a large amount of parental investment in childcare should have been much crucial for child survival. On the other hand, the current environment has much better and novel medical treatment, population health, and social support for

childcare, so raising children can be easier. However, if parents perceive this differently, they could end up with too much parental investment in a smaller number of children. My model includes this effect indirectly, that is, the difference between α that parents "perceive" and its "true" value, because the model does not care whether the value of competitive peer effect that parents perceive is true or not. If parents believe that a competitive peer effect is larger than its real strength, the number of children at ESS should become smaller. To support this idea, it is necessary to reveal that how much the peer competition that parents perceive differs from its real strength. I also need to demonstrate that perceiving higher cost of childcare than its true value was actually adaptive in the EEA.

In my model, I assumed a trade-off between offspring quantity and quality. On the other hand, some previous empirical studies showed that a smaller number of children did not lead to a higher long-term fitness (e.g., Goodman et al., 2012; Kaplan et al., 1995, see also Jones and Bird, 2014; Lawson et al., 2012). Parents' attitude towards having a smaller number of children with high investment may be a reasonable explanation for fertility decline, but this decision-making may be evolutionarily maladaptive at least at a phenotypic level. Therefore, the real strength of competitive peer effect may be weaker than expected, because just having a larger number of children with lower quality can lead to a larger long-term fitness. If this is the case, how parents perceive a competitive peer effect should be more important, rather than its real strength.

As for the effect of resource (i.e., wealth) on fertility, my model predicted that a larger amount of resource (a larger W) leads to a larger number of children (a larger n) and a larger amount of investment for self-investment (a larger a), but it should not affect the amount of investment for child survival (s) and quality (q) *per child* (note that the

total amount of investment for child survival and quality becomes larger because the number of children increases) (Table 5.1). In what follows, I discuss the relevance of my results to the prediction by Mace (2008) that even if there exists a negative or null relationship between wealth and fertility *among* sub-populations, the relationship can be positive *within* a sub-population. Although I did not study the two aspects directly because I assumed one homogenous population in my model, I can discuss this Mace's perspective on the wealth-fertility relationship indirectly based on my results.

My results have indicated that a larger amount of wealth (W) increases fertility (n) (Table 5.1) and that an increase in the importance of child quality (α) and/or self-enhancement (β) reduces fertility (Figure 5.5 and Figure 5.6). As I explained in the Introduction section, it is assumed that the difference in wealth among sub-populations creates a rural-urban gradient. I also assumed that the socioeconomic environment should differ very much among sub-populations. In my model, the rural-urban gradient of the importance of child quality (α) and self-enhancement (β) could also explain Mace's prediction; it is assumed that urban areas should have a competitive environment and many options for self-enhancement, whereas in rural areas where peer competition is milder and there are fewer options for self-enhancement (e.g., Boyd and Richerson, 1985; Kaplan and Lancaster, 2002). In this sense, my results would partly explain the negative effect of wealth in Mace's prediction on fertility among sub-populations. However, my model assumed one homogenous population and did not study inhomogeneity of wealth among sub-populations that is important to study the two aspects of wealth-fertility relationship appropriately. This is one of the limitations of my model. Additionally, I also need to compare the relative impacts between "the effect of wealth that has a positive influence on fertility" and "child quality and self-enhancement

that have negative influences" in my model.

I have found no differences between the results of evolutionary stable strategies (n^*, s^*, q^*, a^*) in the *relative* and *absolute* benefit models. Before the analysis, I expected that if the benefit of self-enhancement is determined relatively to others, the investment to it would be larger due to peer competition - but the result did not support my prediction. However, in this study, I analyzed *multiplicative* models only, that is, I assumed that *Happiness* is the product of biological fitness and psychological satisfaction through self-enhancement. In such a multiplicative model, an extremely biased investment to one component is not an optimum, because the resulting product becomes smaller than a balanced investment. It is important to construct and analyze other types of models, for example, *additive* models, where the *Happiness* is given as the sum of biological fitness and psychological satisfaction through self-enhancement.

This ongoing study has provided new pieces of theoretical evidence regarding fertility decline. However, there are other future works that I need to develop. In my model, I assumed that individuals make a decision regarding their resource allocation only once, but this assumption is unrealistic in a long life of humans. I should improve the present model to incorporate human specific life-history strategies more appropriately.

Lastly, I also discuss the effects of child quality (α) and self-enhancement (β) on *Happiness* at ESS (H^*). My model predicted that the increases in the importance of self-enhancement and child quality should reduce the *Happiness* at ESS (Figures 5.7 to 5.10). The result may be undesirable in real life because the *Happiness* becomes very small in societies with a high level of peer competition and many options for self-enhancement. These two characteristics seem to reflect modern developed societies very well. My model produces a new and big

question: *What are the components of happiness for parents in a current competitive environment?*

Figure legends

Figure 5.1. The survival function (S).

Figure 5.2. The resource constraint that parents face.

Figure 5.3. The effect of importance of child quality (α) on the function of children's mating success (Q).

Figure 5.4. The effect of importance of self-enhancement (β) on the function of psychological satisfaction (A).

Figure 5.5. The effect of importance of child quality (α) on the number of children at ESS (n^*).

Figure 5.6. The effect of importance of self-enhancement (β) on the number of children at ESS (n^*).

Figure 5.7. The relationship between the importance of child quality (α) and the level of *Happiness* at ESS (H^*) in the relative benefit model.

Figure 5.8. The relationship between the importance of self-enhancement (β) and the level of *Happiness* at ESS (H^*) in the relative benefit model.

Figure 5.9. The relationship between the importance of child quality (α) and the level of *Happiness* at ESS (H^*) in the absolute benefit model.

Figure 5.10. The relationship between the importance of

self-enhancement (β) and the level of *Happiness* at ESS (H^*) in the absolute benefit model.

Table captions

Table 5.1. A summary of results of my models.

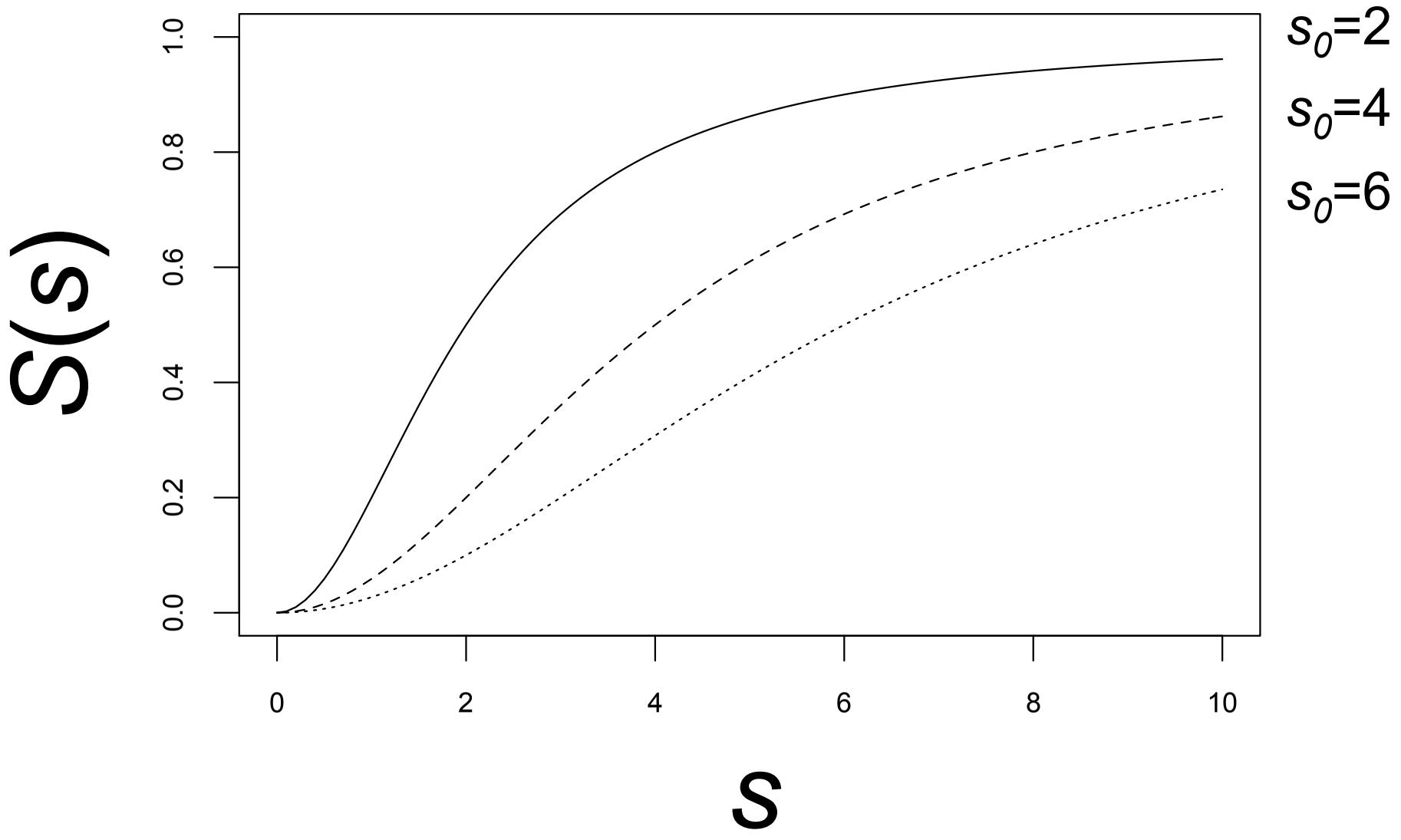

Fig. 5.1 The survival function (*S*)

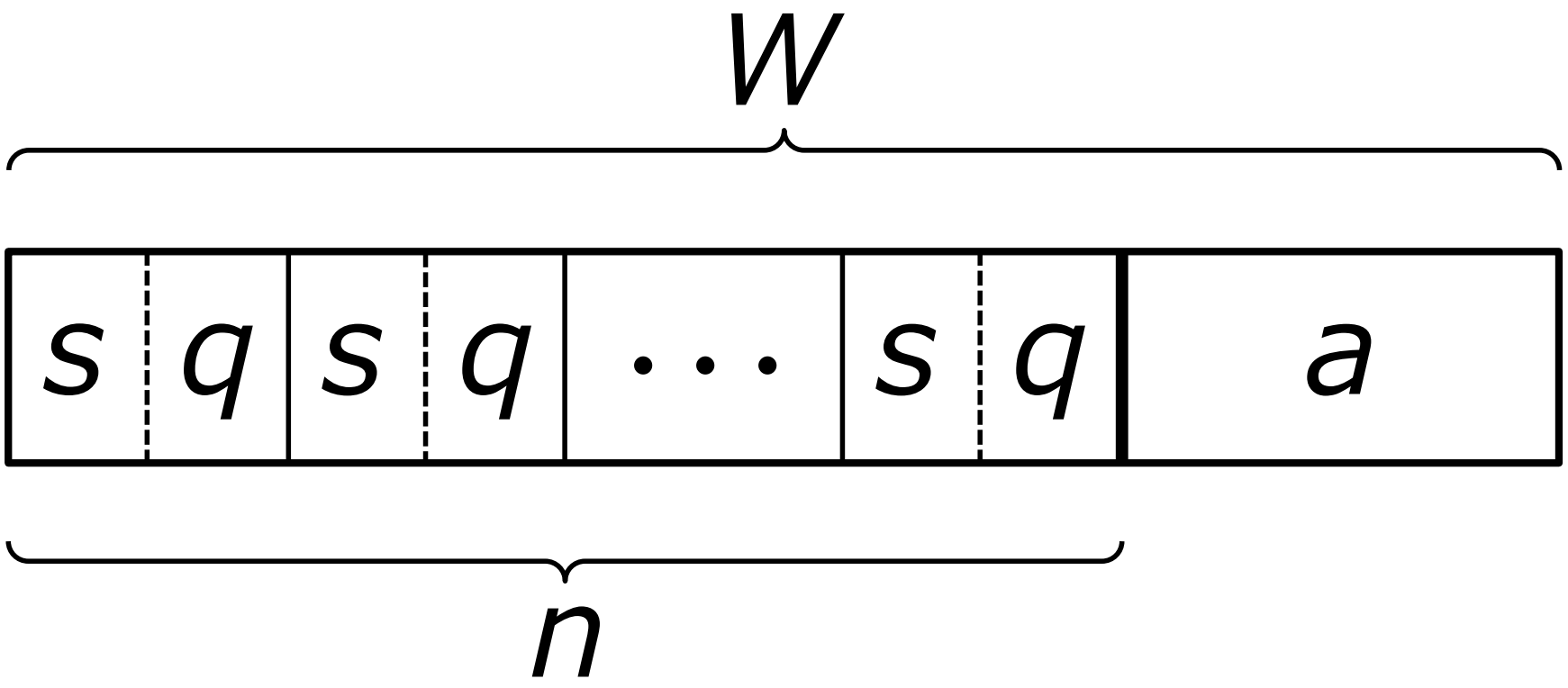

Fig. 5.2 The resource constraint that parents face

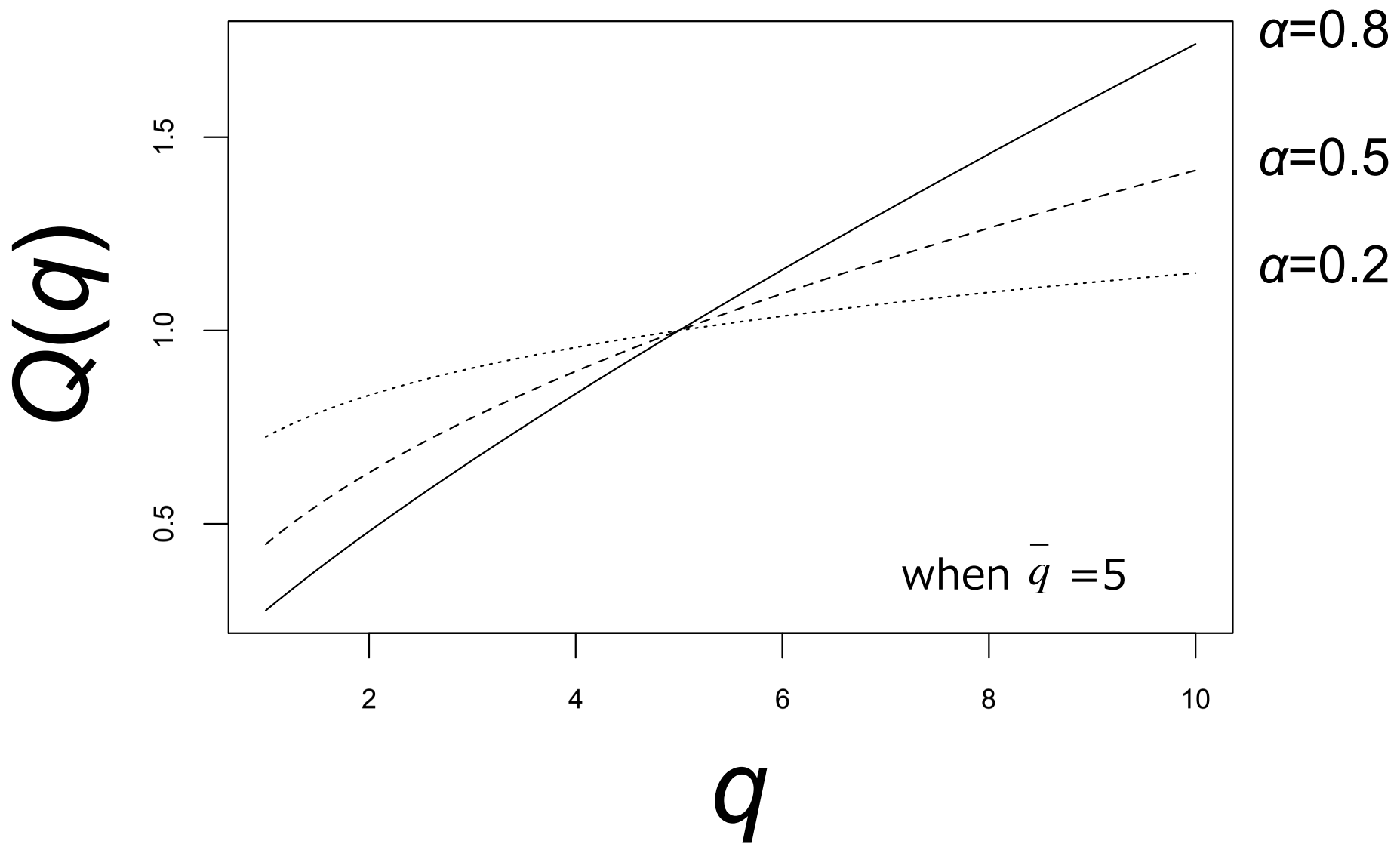

Fig. 5.3 The effect of importance of child quality (α) on the function of children's mating success (Q)

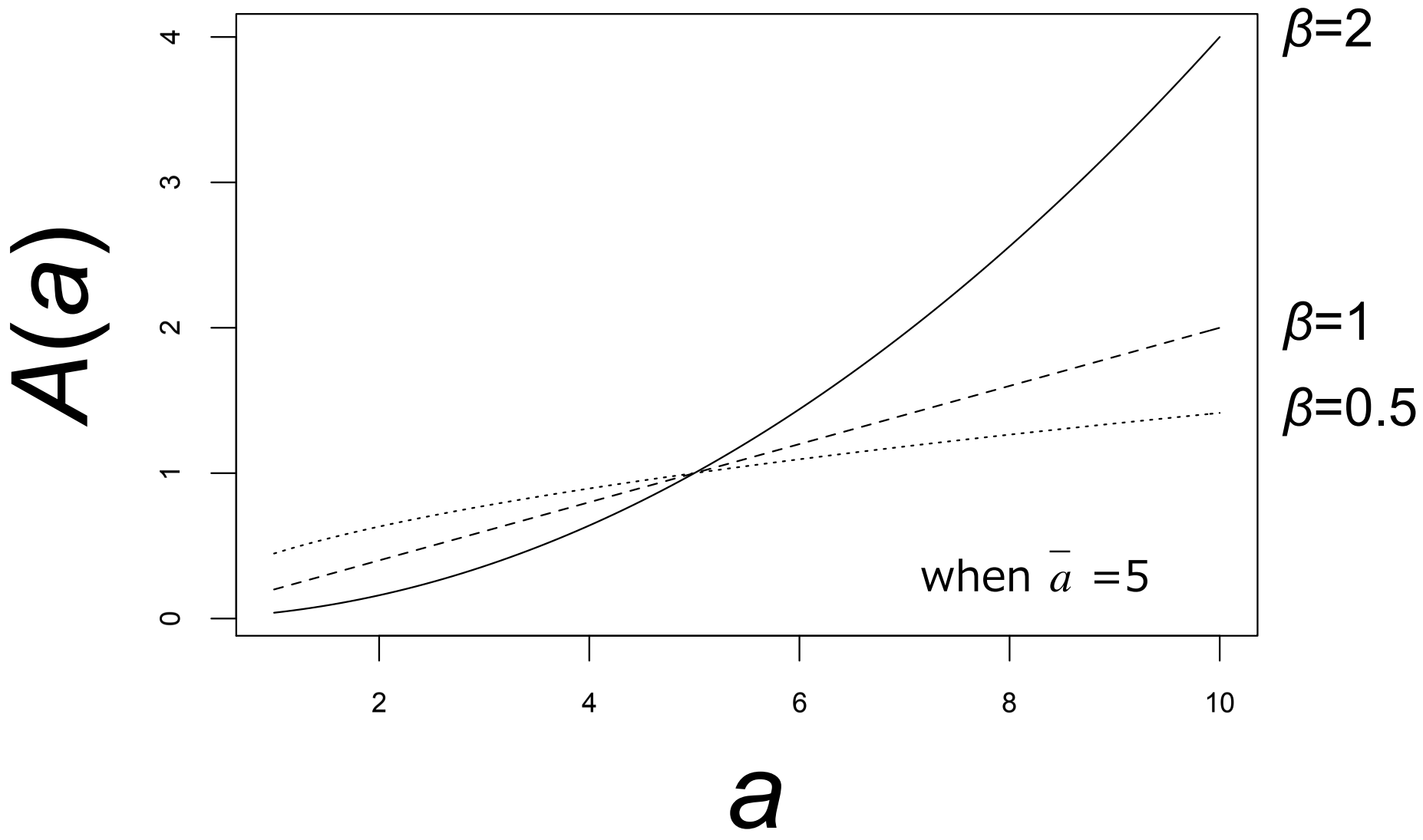

Fig. 5.4 The effect of importance of self-enhancement (β) on the function of psychological satisfaction (A)

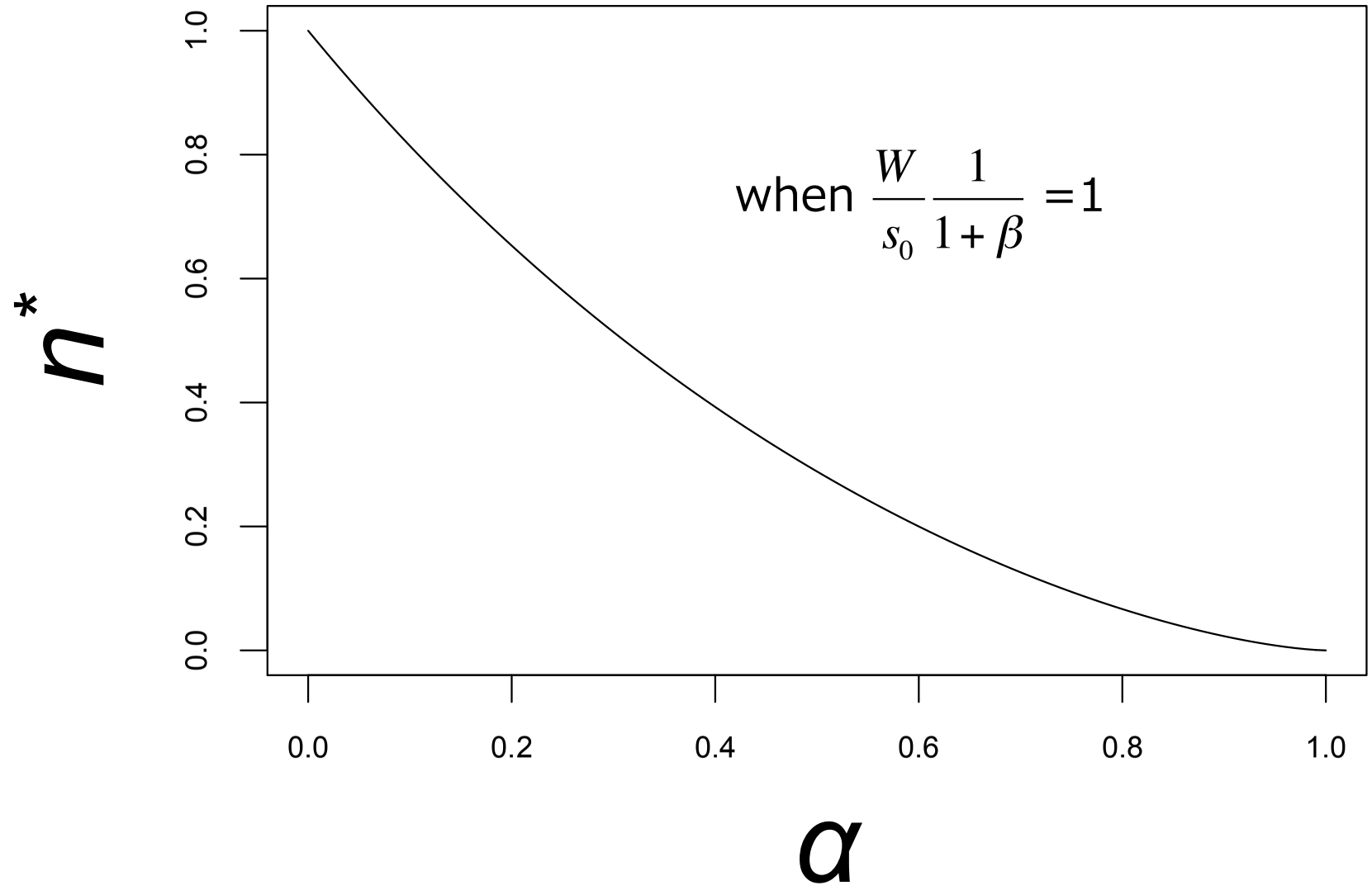

Fig. 5.5 The effect of importance of child quality (α) on the number of children at ESS (n^*)

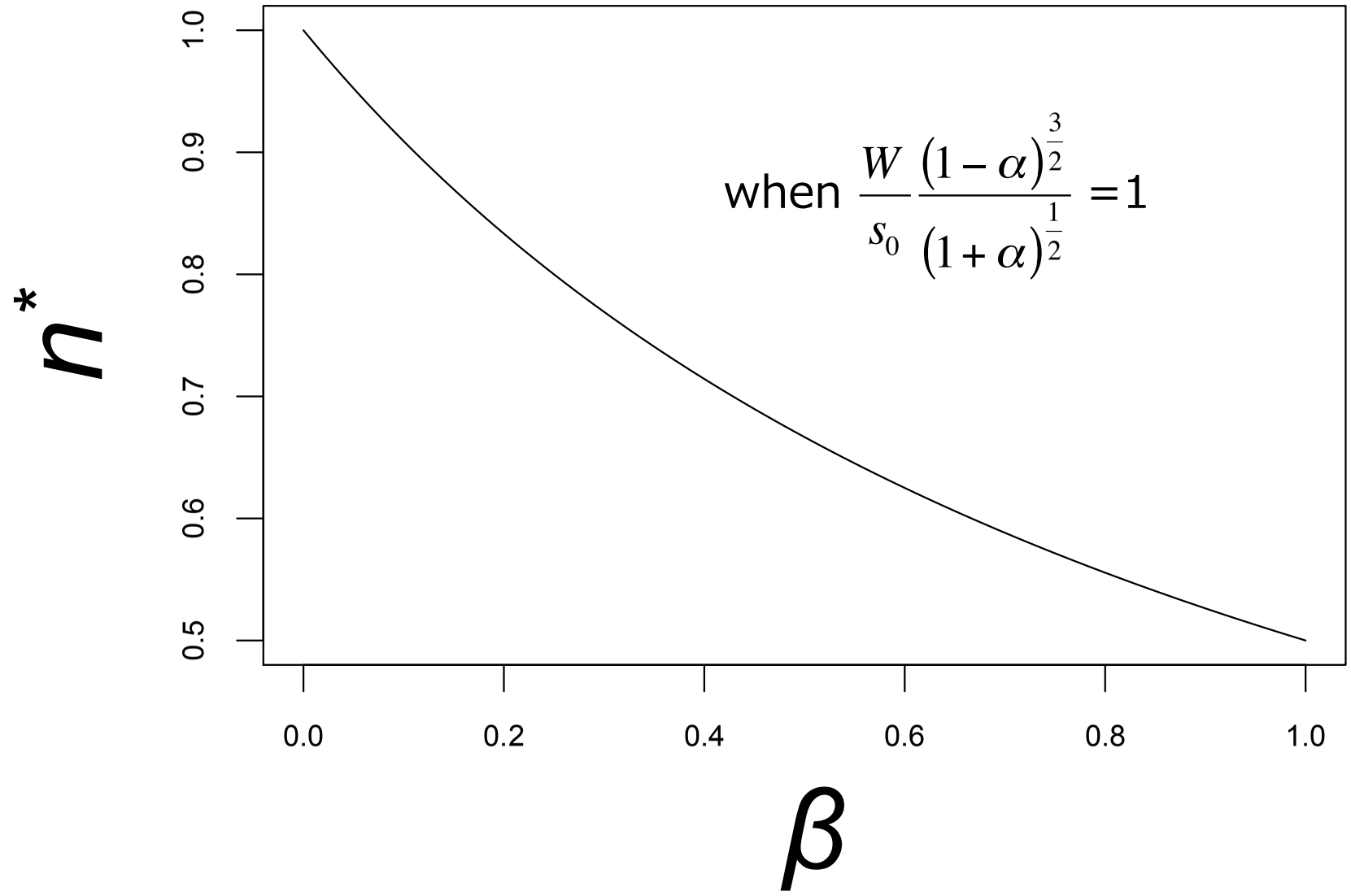

Fig. 5.6 The effect of importance of self-enhancement (β) on the number of children at ESS (n^*)

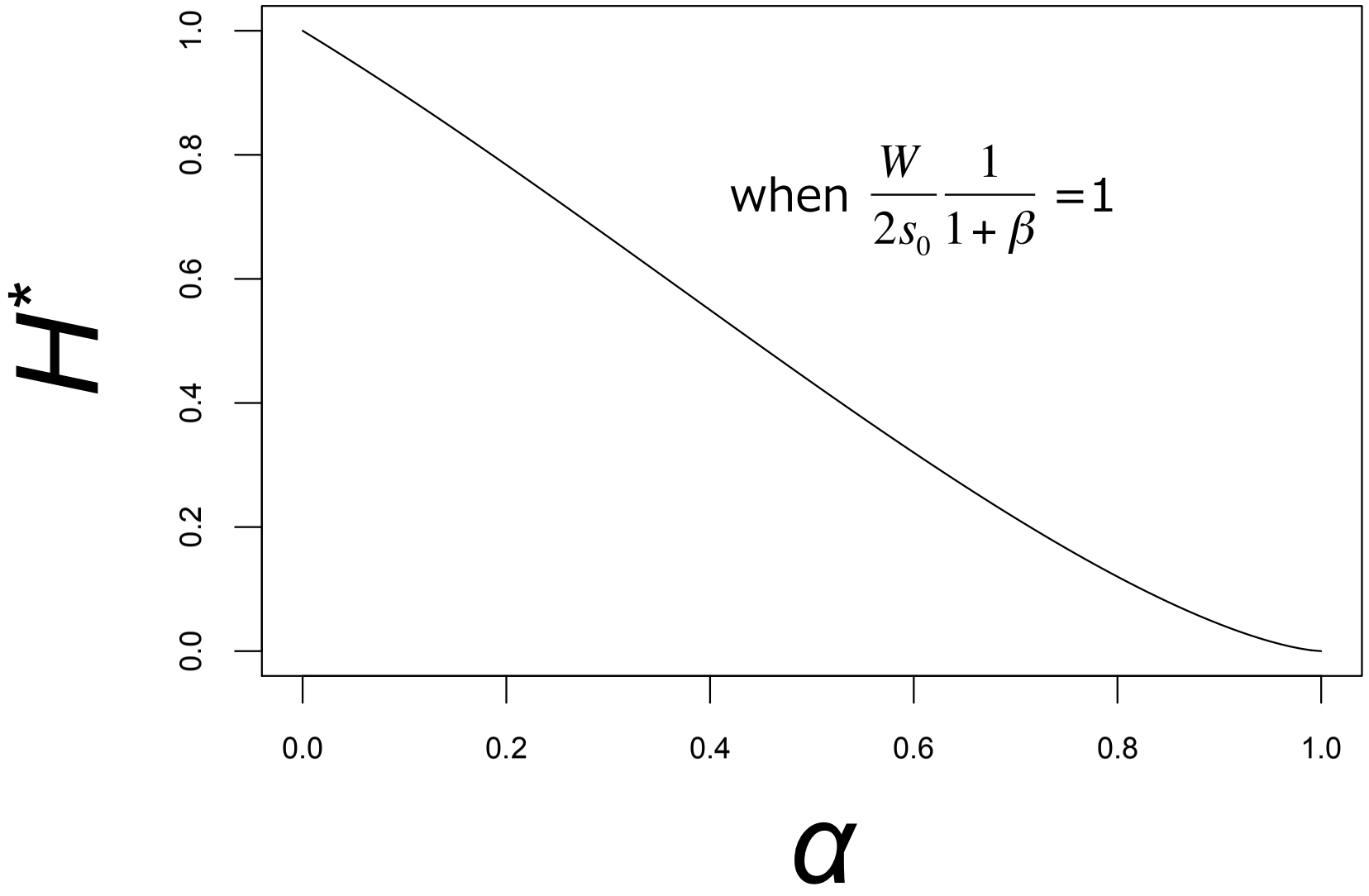

Fig. 5.7 The relationship between the importance of child quality (α) and the level of *Happiness* at ESS (H^*) in the relative model

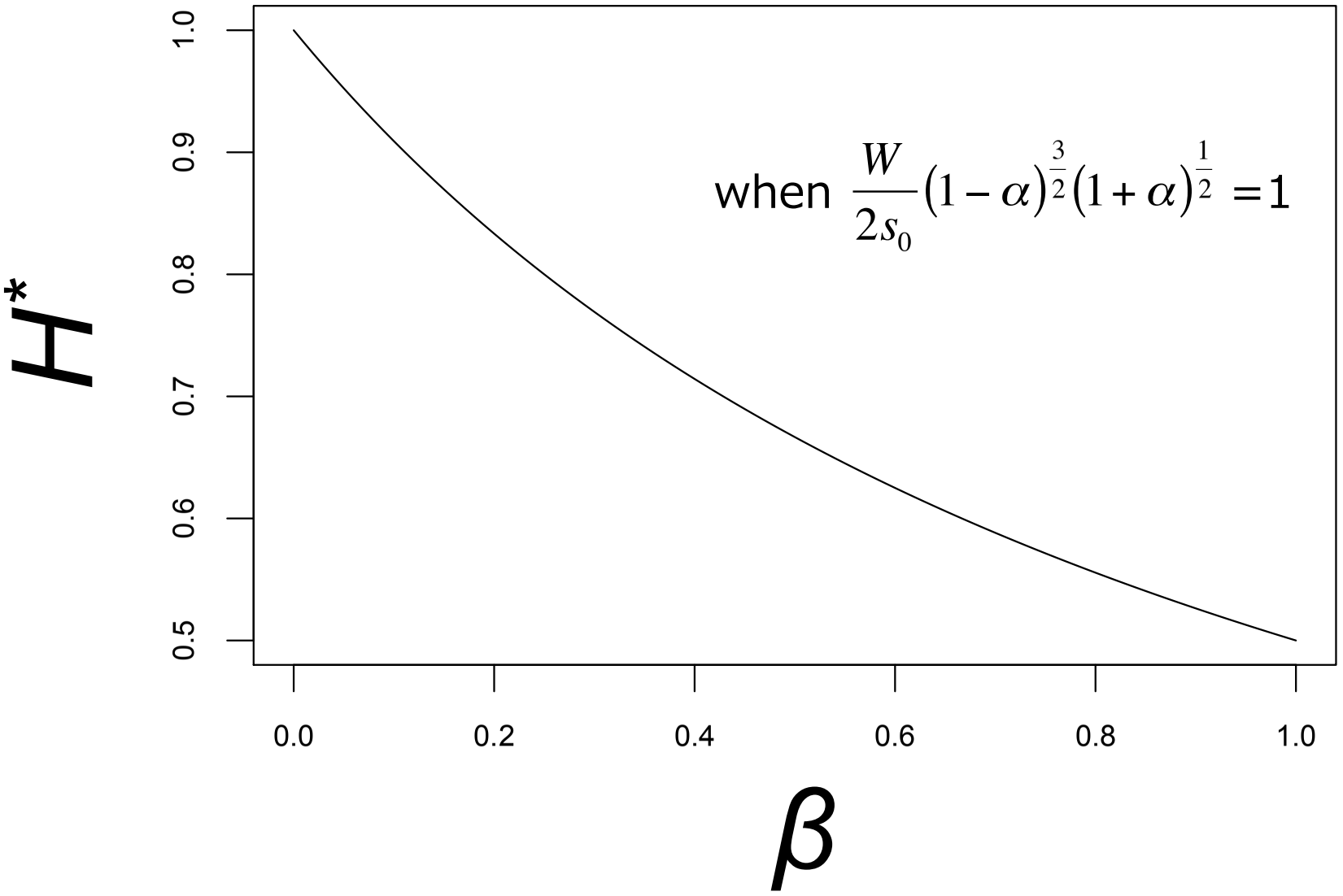

Fig. 5.8 The relationship between the importance of self-enhancement (β) and the level of *Happiness* at ESS (H^*) in the relative model

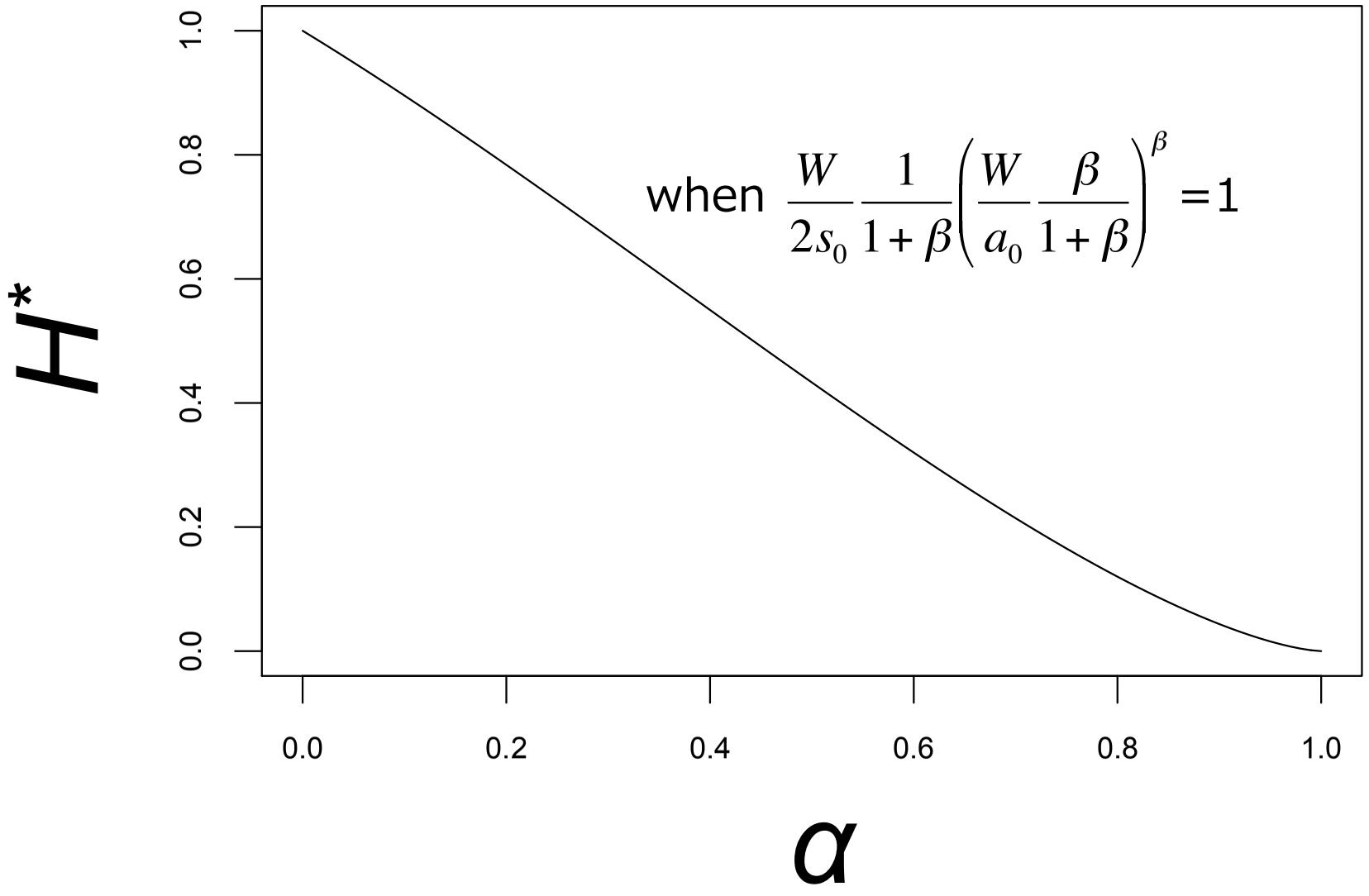

Fig. 5.9 The relationship between the importance of child quality (α) and the level of *Happiness* at ESS (H^*) in the absolute model

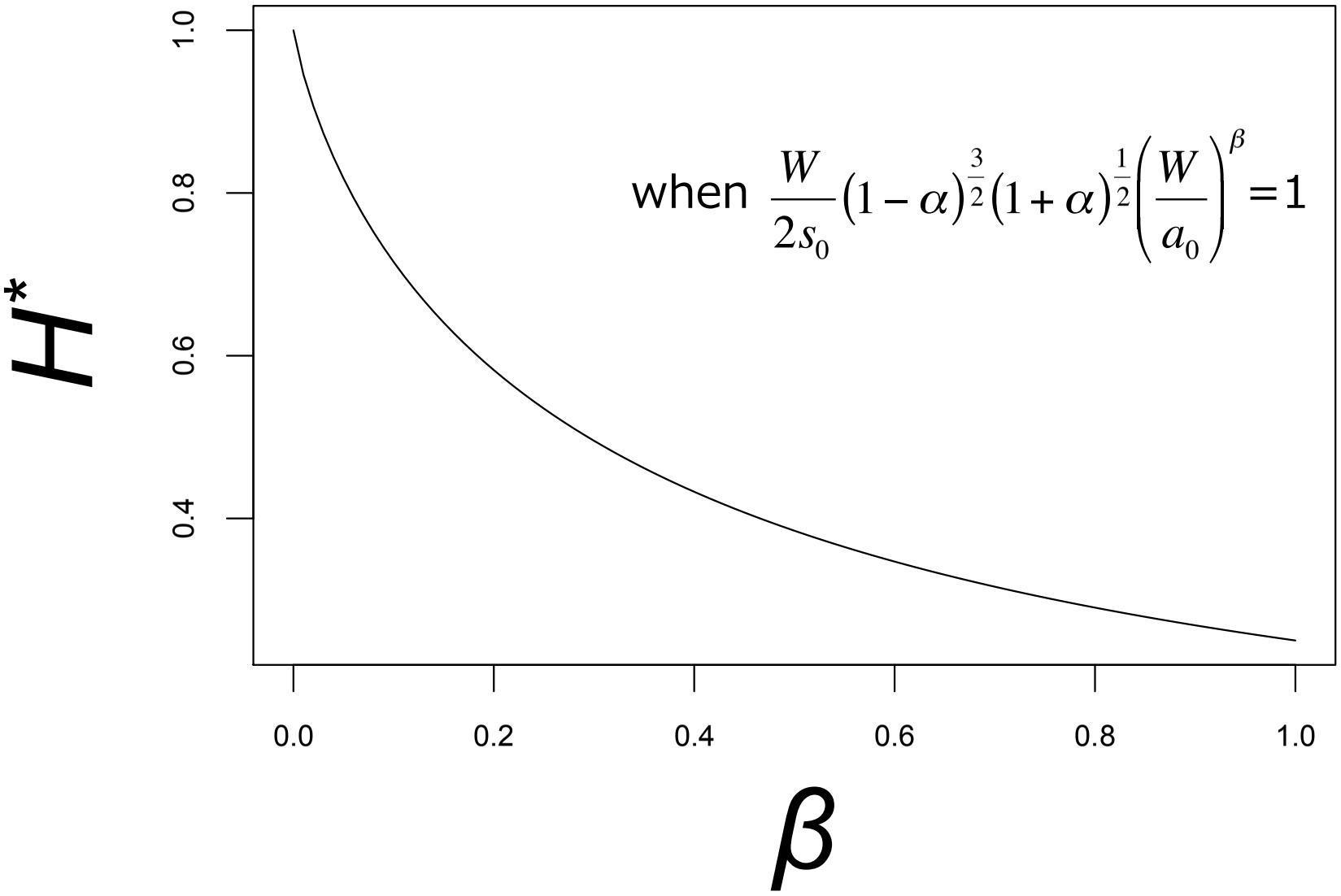

Fig. 5.10 The relationship between the importance of self-enhancement (β) and the level of *Happiness* at ESS (H^*) in the absolute model

Table 5.1 A summary of the results from my models

Multiplicative model with a relative and an absolute benefit of self-enhancement

	$W\uparrow$	$s_0\uparrow$	$\alpha\uparrow$	$\beta\uparrow$
n^*	↑	↓	↓	↓
s^*	-	↑	↑	-
q^*	-	↑	↑	-
a^*	↑	-	-	↑

↑: increase, ↓: decrease, or -: no effect

Chapter 6

General Discussion

6.1. Summary of the results

In the first place, I summarize the results of each chapter. My PhD study examined various topics that are strongly related to fertility decline, especially that in modern Japan, with evolutionary perspectives. In Chapter 2, I studied factors affecting the number of children by analyzing cross-sectional data. In particular, I focused on the effects of one's socioeconomic status, such as income or education level, on the number of children. I have found that one's socioeconomic status did not have positive effects on the number of children. The unique factor that significantly affected the number of children was the age at first marriage, which had a negative effect. I have also found that interaction terms between sex and socioeconomic status were not significant. In Chapter 3, I studied factors affecting the probability of childbirth by analyzing panel data. The analysis has revealed the conditions preceding childbirth that should be important in the process of reproductive decision-making. I have found that good parental conditions for childcare, such as high income, increase in income, or co-residence with parents (i.e., co-residence with grandparents of children), did not have positive effects on the probability of childbirth. In addition, I have shown that the presence of two children strongly prevented further childbirth. In Chapter 4, I studied sexual conflict between mother and father (i.e., their husband) over reproductive decision-making within a couple by conducting a questionnaire survey at a childcare facility. I have found no clear evidence of sexual conflict between mother and father (her husband) over the ideal number of children. I have also found that parents had equal power to have a next child. In Chapter 5, I studied

effects of peer competition among offspring and psychological satisfaction through self-enhancement (i.e., options other than reproduction) on fertility decline by constructing a mathematical model. My model theoretically predicts that (1) a high level of investment for child quality against a competitive environment and (2) a high level of investment for self-enhancement reduce one's fertility. It also predicts that possessing a larger amount of resources leads to a higher fertility. My model deviates from a purely evolutionary one, but this expansion should be helpful to reveal human life-history strategies.

As I described above, I have obtained a number of results on fertility decline by taking a variety of approaches. I have contributed to providing a novel framework and pieces of evidence that are related to fertility decline. In particular, I believe that Chapter 3 and Chapter 4 have much large impacts on evolutionary studies of fertility decline. In Chapter 3, I have clearly shown the benefit of analyzing panel data, compared with analyzing cross-sectional data, for studying human reproductive strategies regarding fertility. In addition, I have shown new quantitative evidence of the preference for the number of children that is called "two-child norm". The result will help us understand evolutionarily maladaptive norms that humans have. In Chapter 4, I have provided information about sexual conflict between mother and father over reproductive decision-making in a modern, developed, and low-fertility society. Until now, few empirical studies have been conducted that analyzed the effect of sexual conflict on fertility decline in such a society. Therefore, I believe that my studies have contributed to revealing an evolutionary background of conflicts between the two-sexes in humans. Moreover, my studies are important because there existed few previous studies that analyzed Japanese data. In fact, some of my results did not confirm those reported in previous studies based on the data of Europe and the USA. This distinction is significant in

studying effects of cultural and social environments on human behavior.

6.2. Socioeconomic success versus reproductive success

In this section, I discuss the relationship between socioeconomic success and reproductive success. In general, theories of behavioral ecology predict that there exists a positive relationship between the amount of resources / one's status and reproductive success (e.g., Barthold et al., 2012; Hopcroft, 2006, 2015, see also Ellis, 1995). However, researchers found few positive relationships between socioeconomic status and reproductive success in modern developed societies (e.g., Barthold et al., 2012; Borgerhoff Mulder, 1998; Hill and Reeve, 2005; Kaplan and Lancaster, 2000, 2003). In such studies in modern developed societies, income and education levels are often used as measures of one's socioeconomic status. Vining (1986) concluded that such a non-positive relationship between socioeconomic status and reproductive success is a great challenge to evolutionary approaches to human behavior (see also the Introduction sections of Chapter 2 and Chapter 3 for detailed discussions).

In Chapters 2 to 4, I found no clear positive relationships betweens one's socioeconomic success (i.e., high household income or high education level) and reproductive success (i.e., a larger number of children, a higher probability of childbirth, or a larger ideal number of children) in my statistical analyses of empirical data. These results generally confirmed findings in previous studies (at least, I and other researchers did not find that a higher socioeconomic success led to a higher reproductive success). In modern developed societies, it is easily expected that individuals invest a great amount of effort for enhancing their socioeconomic status. However, why do they seek high socioeconomic success that does not lead to high reproductive success? This question is a puzzle to evolutionary approaches.

According to the discussion by Hillard Kaplan, Jane B. Lancaster, and their colleagues (e.g., Kaplan, 1996; Kaplan and Lancaster, 2000, 2003; Kaplan et al., 1995, 2002; Snopkowski and Kaplan, 2014), in modern developed societies with a skills-based competitive labor market and a subsequent competitive mating market, individuals in lower quality should have lower reproductive success than ones in higher quality. It is because lower quality ones will tend to lose in a peer competition over jobs and marriage. Therefore, parents should set a high value on parental investment in their children and would aim to produce a smaller number of high-quality children (see also Chapter 5 for a piece of theoretical evidence).

It is also suggested that parents keep high own socioeconomic status in order to provide high-levels of parental investment to their children (e.g., Goodman et al., 2012; Gibson and Sear, 2010; Hedges et al., 2016; Kaplan et al., 1995, 2002; Snopkowski and Kaplan, 2014). Kaplan et al. (2002) showed that parent's education level had a positive effect on their children's education level in the modern USA. Hedges et al. (2016) focused on the shift of parental investment associated with the demographic transition. Using the data of northern Tanzania, they studied the effects of parents' socioeconomic status on their children's education level and strategies of parental investment. They showed that household wealth had positive effects on education outcomes in children and that parents of wealthy household (this is related to that they are not pastoralists or farmers but business-owners) perceived higher economic pay-offs regarding parental investment in their children's education. Snopkowski and Kaplan (2014) analyzed Bolivia data and synthetically showed the paths from (1) higher parents' education level, to (2) more parental investment in their children's education, to (3) children's higher education level, to (4) parents' giving birth at a later age, and to (5) a lowered total fertility. Gibson and Sear (2010) showed that, in rural

Ethiopia and rural Malawi, household wealth had overall a positive influence on children's education level. They also confirmed biased parental investment in wealthy households to specific children among siblings that enables parents to have high-quality children. They suggested that such biased parental investment is one of the reproductive strategies against peer competition among offspring and would be also related to having a smaller number of children with high levels of parental investment (i.e., a feature in low-fertility societies).

Although the latter three studies were based on the analyses of data in not "modern developed" societies, they provided valuable insights for understanding the socioeconomic transition from traditional/rural to modern/urban competitive societies and for the following demographic transition to fertility decline. However, there are few previous studies with an evolutionary perspective that examined the effects of parents' socioeconomic status on their children's socioeconomic status and strategies of parental investment using a modern developed, low-fertility society (see also Hedges et al., 2016). The data of current Japan that I used for the analyses in this thesis will have a potential to fill the gap. I leave this as one of my future works.

On the other hand, empirical studies showed that a smaller number of children did not lead to a higher long-term fitness (Goodman et al., 2012; Kaplan et al., 1995, see also Jones and Bird, 2014; Lawson et al., 2012; Strassmann and Gillespie, 2002). Goodman et al. (2012) showed that fertility limitation increased descendants' economic success, but reduced long-term reproductive success in a modern Swedish society. Kaplan et al. (1995) showed that a larger number of children simply led to a larger number of grandchildren in the modern USA. These pieces of evidence mean that reproductive decision-making by parents that limit the number of children may not work adaptively in terms of fitness maximization. To better understand this seemingly evolutionarily

maladaptive decision-making, it is necessary to study not only the contribution of parents' socioeconomic success to their reproductive success and their parental investment but also how parents perceive their socioeconomic status. For example, in Chapter 5, I have provided an idea of maximization of *"Happiness"* (i.e., the combination of biological fitness and self-investment). I believe that evolutionary approaches enable us to find the ultimate factors of fertility decline (see also 6.4). By clarifying the aforementioned point (i.e., psychological basis regarding socioeconomic success), I will be able to answer the question of why the fertility decline occurs.

Moreover, as I discussed in Chapter 5, Mace (2007 and 2008) provided a deeper perspective regarding the relationship between socioeconomic success and reproductive success; even if there exists a negative or null relationship between wealth (i.e., socioeconomic success, in my viewpoint) and fertility *among* sub-populations, the relationship can be positive *within* a sub-population (see also Alvergne and Lummaa, 2014 for empirical evidence). However, in my analyses of empirical data, I did not take into account the perspective of "sub-population". According to the argument in Mace (2007 and 2008), the wealth means a rural-urban gradient (i.e., people in rural societies have lower wealth and those in urban societies have higher wealth) and it is assumed that socioeconomic environment should be quite different among sub-populations. In the same way as my theoretical study in Chapter 5, I assumed that, in modern fully developed societies including Japan, there would be no clear rural-urban gradient and that socioeconomic environments would be homogenous. This means that there should exist no clear sub-populations in Japan. However, I did not actually confirm whether this assumption was reasonable or not in my analyses. I leave this as one of my future works, too.

In addition, I briefly discuss the effect of contraception on the

relationship between socioeconomic success and reproductive success. Some previous studies showed a positive relationship between one's socioeconomic success and mating success, such as frequency of sex, for men (e.g., Kanazawa, 2003; Pérusse, 1993, bus see also Hopcroft, 2006; Nettle and Pollet, 2008). If sexual satisfaction or sexual desire, rather than its reproductive outcomes, such as the number of offspring, has a more important role in human psychological mechanisms, modern fertility decline under effective birth control methods and rich porno industries may be easily understood (but see also Borgerhoff Mulder, 1998). Contrary to people in pre-industrial societies, a link between mating success and reproductive outcomes is very loose in post-industrial societies, because of the wide-spreading effective contraception. Currently, people can obtain sexual satisfaction without a variety of cost of childbearing and childcare (e.g., time, economic, physical, or mental cost). Contraception may have a function to loosen the relationship between socioeconomic success and reproductive success.

Lastly, I would also like to pose another discussion. As I explained in this thesis, many researches currently assume as their central concept that theories from behavioral ecology should predict a positive relationship between one's socioeconomic status and the number of offspring. However, in modern developed societies, where (1) having multiple mating relationships is socially banned strictly, (2) variation of one's socioeconomic status in the population is relatively small compared with historical societies, such as despotic and hierarchical ones (see also Colleran et al., 2015), (3) parental costs for childcare to prepare for peer competition among offspring are quite large, (4) effective birth-control methods are easily available, and (5) there are numerous attractive options other than reproduction, how much a high socioeconomic status can actually lead to a large number of children? In

modern developed societies it could be the case that (1) getting married with an appropriate partner at a young age and (2) having children as fast and as many as possible without worrying about parental investment for children can lead to a large number of children. However, few individuals would seek this scenario. We may need to reconsider the theoretical framework and concept to study the relationship between one's socioeconomic success and reproductive success in modern developed societies. Until now, many studies have analyzed "how socioeconomic success contributes to reproductive success" (i.e., behavioral/phenotypic aspect). In addition to such an approach, as I suggested earlier, "why individuals seek high socioeconomic success that does not directly enhance reproductive success" (i.e., psychological aspect) should also be considered.

6.3. Effects of various kinds of sexual conflict on fertility decline

In Chapter 4, I studied fertility decline from the perspective of sexual conflict. I focused on sexual conflict between mother and father (her husband) over reproductive decision-making within a couple there. More specifically, I mainly analyzed sex differences in the ideal number of children. The results of my questionnaire survey in an urban area in current Japan did not support my hypothesis. I found no sex differences in the ideal number of children within a couple in many cases. However, as I discussed in Chapter 4, it may be premature to conclude that there is/was no sexual conflict between mother and father in Japan, because I studied only a limited number of aspects of sexual conflict at one time period. In this section, I consider effects of various kinds of sexual conflict on fertility decline.

There are various measures other than family size to study sexual conflict between parents (reviewed in Borgerhoff Mulder and Rauch, 2009, see also Mace, 2013, for a review on reproductive conflict between

women in the family). For example, sexual conflict over contraceptive (i.e., modern birth-control methods) use has been studied (e.g., Borgerhoff Mulder, 2009a; Mace and Colleran, 2009). Borgerhoff Mulder (2009a) analyzed the data of horticulturalists in Tanzania, who have unstable marriage and little polygyny (see also Borgerhoff Mulder and Rauch, 2009). She showed that women who had a constant husband (i.e., living with the same husband for an interim period) tended to be not successful in using contraception to lower the rate of their reproduction. She suggested a possibility that *"women in long-term marriages might be constrained to reproduce according to their husband's (generally higher) preference"* (Borgerhoff Mulder, 2009a, p. 485). Mace and Colleran (2009) showed that women with their husband (i.e., not in widowhood) started to use birth-control methods lately in rural Gambia. There are several possible interpretations of these results, but these two pieces of evidence indicate that there can be sexual conflict between mother and father over contraceptive use within a couple.

As I discussed in the previous section, contraception enables people to control their pregnancy and reproductive outcomes very easily and it should have a large impact on fertility decline (but see also Borgerhoff Mulder, 1998). The perspective from sexual conflict between mother and father will promote a more evolutionary understanding of contraceptive use and will also lead to a deeper understanding of fertility decline.

Next, I shed light on another aspect; sexual conflict over induced (artificial) abortion (see also Schlomer et al., 2011 for a review on spontaneous abortion). To my knowledge, there are few studies on sexual conflict between mother and father over induced abortion within a couple and its effect on fertility decline. In Japan, induced abortion was legalized in 1948 and the legal procedure for receiving a treatment was

simplified in 1952. I show the change of the induced abortion rate and that of the total fertility rate in Japan in Figure 6.1 (the data were derived from National Institute of Population and Social Security Research, 2015, see also Sato and Iwasawa, 2006). According to Figure 6.1, the decrease in the total fertility rate and the increase in the induced abortion rate occurred in the same period, from 1949 to the 1950s.

In this period, gender equality was only partially achieved in Japan, so I think that sexual conflict could be clearly revealed from the data in that period. It is because I predict that there was a stronger conflict within a couple in that period than present (see Chapter 4 for details). Based on this prediction, I provide one possible explanation of the change of the total fertility rate and that of induced abortion. My reasoning is that before the legalization of induced abortion, there must be a number of undesirable childbirths forced by husbands because evolutionary theories predict that men should want a larger number of children than their wife.

However, my explanation above is still just a speculation. I have not studied power balance between women and her husband in choosing the option of induced abortion. Even after the legalization of induced abortion, a question remains as to how women managed to receive induced abortion? If men (still) had more power in reproductive-decision making even after the legalization, fertility decline cannot occur because induced abortion cannot often be practiced by women. Also, I have no data on the sex differences in the ideal number of children within a couple in that period. In order to reveal these points, I need to analyze historical data at that time. I leave this project as one of my future works.

In this section, I discussed two measures of sexual conflict other than family size: contraception and induced abortion. As I wrote in Chapter 4, a human couple has often been viewed as a cooperative unit

with common reproductive goals (Shackelford et al., 2012). There are a limited number of evolutionary studies on fertility decline with the perspective of sexual conflict. In my thesis, I have studied fertility decline from the viewpoint of sexual conflict and have provided novel empirical evidence and some future directions.

6.4. Relationship between evolutionary biology and social sciences

Numerous studies on fertility decline have been conducted in social sciences (e.g., demography, sociology, and economics). According to Borgerhoff Mulder (2009a), there are three primary economic explanations for fertility decline: (1) large cost of childbearing (e.g., Caldwell, 1982), (2) less availability of family support (e.g., Turke, 1989), and (3) high cost of reproduction contingent on women's employment (e.g., Handwerker, 1993). In evolutionary perspectives, the first explanation corresponds to the theory of trade-offs between offspring quantity and quality, the second one corresponds to the theory of cooperative breeding, and the third one corresponds to the theory of sexual conflict between mother and father to some extent. These exchangeable explanations mean that evolutionary biology and social sciences have a potential to communicate with each other complimentarily.

Until now, there exist few integrated studies between evolutionary biology and social sciences. Researchers in each discipline are interested in the same phenomenon, so integrated studies between them are desirable. Studies in social sciences have mainly revealed the question of "*HOW* fertility decline occurs". On the other hand, evolutionary thinking enables us to consider the question of "*WHY* fertility decline occurs" (because it is a paradoxical phenomenon for evolutionary biology). Evolutionary biology provides a concise and rigid theoretical framework to study human behavior based on fitness maximization. The

integration of these disciplines will lead to a better understanding of fertility decline (see also Sear, 2015).

6.5. Towards an integrated understanding of fertility decline and other evolutionarily (mal)adaptive behaviors in humans

As a last section of General Discussion, I provide an perspective towards an integrated understanding of fertility decline and other evolutionarily (mal)adaptive behaviors. Currently, there are three evolutionary approaches to human behavior (e.g., Nettle, 2009; Sear, 2007; Smith, 2000, see also Laland and Brown, 2011). These are: (1) human behavioral ecology (Chagnon and Irons, 1979; Nettle et al., 2013), (2) evolutionary psychology (Barkow et al., 1992), and (3) dual inheritance theory / cultural evolution (Boyd and Richerson, 1985; Richerson and Boyd, 2005).

In human behavioral ecology, researchers aim to clarify the adaptiveness of human traits to the current environment at a phenotypic level. On the other hand, as I mentioned in Chapter 5, evolutionary psychology sheds light on the adaptation of human mechanisms to the ancestral environments (EEA: Environment of Evolutionary Adaptation). Therefore, evolutionary psychologists are mainly interested in not behavior observed in the current environment but evolved psychological mechanisms generally underlying each behavior (note that we can also study the adaptation of not only psychological mechanisms but also current physical traits to their ancestral environments from a similar perspective). There exist some ecological differences between the EEA and the current environment. An example is preference for sugary and fatty foods. Such food is valuable but scarce in the ancestral environment, so seeking the taste should be adaptive. On the other hand, sugar and fat are abundant in the current environment, so preference for them often causes health issues and maladaptive results (e.g., Nettle,

2009). Owing to the mismatch between these environments, evolved mechanisms that were adaptive in the past do not always work adaptively in the current environment, and they can lead to maladaptive behavior (see also Barrett and Stulp, in press). Dual inheritance theory pays attention to cultural evolution. An example of process that drives cultural evolution is imitation (in other words, social learning). By imitating socially successful others, one can behave adaptively at a lower cost of learning. In this perspective, imitation can be adaptive. However, culture can *sometimes* be transmitted to the next generation regardless of its effect on genetic success (i.e., fertility). Due to this feature, culture would also generate maladaptive behavior *in some cases* in terms of genetic evolution.

I show an application of the aforementioned three approaches to fertility decline. Below I repeat what I explained in Chapter 1. Borgerhoff Mulder (1998) summarized three evolutionary hypotheses to explain fertility decline. I aim to explain that each approach corresponds to each hypothesis. (1) From the perspective of human behavioral ecology: having a small number of children, but with high levels of parental investment, should be adaptive in the current competitive environment with a skills-based competitive labor markets a and subsequence competitive mating market. This hypothesis assumes a trade-off between offspring quality and quantity and a peer competition among offspring. (2) From the perspective of evolutionary psychology: the decline of birthrates should be a maladaptive by-product of a mismatch between the evolved mechanisms and the current environment that rapidly changed from the ancestral one. It is discussed that the invention and the wide-spreading use of contraception may be an example of the rapid change leading low birthrates. However, it is not clear what is the mismatch in this scenario. (3) From the perspective of dual inheritance theory / cultural evolution: the modern low fertility

should be a maladaptive output led by non-genetic cultural transmission; such as imitation of socially successful, but not necessarily reproductively successful, other individuals. If some traits that lead to a small number of children are culturally preferred, fertility decline could occur.

In my PhD study, I have obtained some results that are related to these three hypotheses. For example, my result on the two-child norm (see Chapter 3) may be explained well by the third hypothesis. However, I have not fully considered the relationship between the results in my thesis and Borgerhoff Mulder's three hypotheses. Also, I have not directly tested which hypothesis or what combination of them is the most important in explaining the fertility decline in Japan (and in other countries). To answer this question, I need to construct predictions that can clearly distinguish the relative strength of each hypothesis.

In my thesis, I focus on fertility decline only. However, as I listed in Chapter 1, there exist several (seemingly) evolutionarily maladaptive behaviors/phenomena in humans other than fertility decline. Child abuse, menopause, and suicide are typical examples. They often entail a decrease in one's reproductive fitness (i.e., are maladaptive), so they seem to be paradoxical in the evolution of human behavior, too. The inclusive fitness theory (Hamilton, 1964) can reasonably explain the paradox in part (especially for child abuse), but cannot all (especially for suicide). I believe that the integration of three approaches mentioned above (i.e., human behavioral ecology, evolutionary psychology, and dual inheritance theory / cultural evolution) has a potential to explain many kinds of human evolutionarily (mal)adaptive behaviors in a simple framework. Such an attempt will be able to generate a wide understanding of human behavior, ecology, psychology, and culture beyond each single topic. I will continue to develop and expand the present study on fertility decline for that purpose in my future work.

Figure legends

Figure. 6.1. The change of the total fertility rate and that of the induced abortion rate in Japan.

The solid line shows the total fertility rate and the dotted line shows the induced abortion rate.

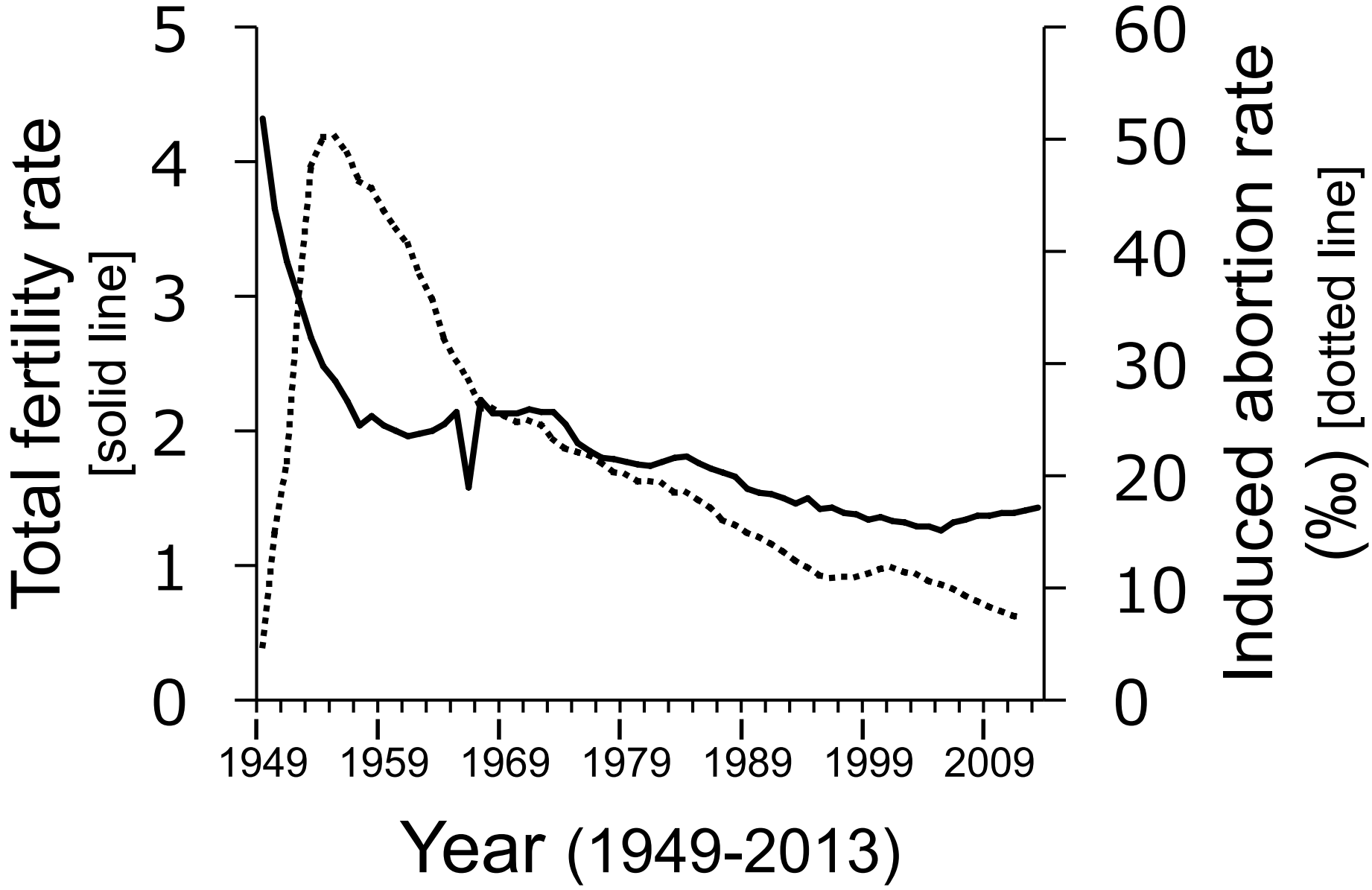

Fig. 6.1 The change of the total fertility rate and that of the induced abortion rate in Japan

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Appendix

I show the questionnaire sheets (as an example, those for mothers and fathers with two children) and other documents (in Japanese) used in my study of Chapter 4 from the next page.

結婚・出産・子育てに関するアンケート調査

✓本調査は、国立大学法人 総合研究大学院大学教授の長谷川眞理子と、大学院生の森田理仁（もりたまさひと）が中心となり実施するものです。

✓子育て世代の方々を対象に、日本人の結婚・出産・子育てについて、学術的な視点から研究することを目的としています。

✓あなたご自身のほか、配偶者やお子さんについての質問が含まれています。回答は集計して分析に用いるため、個人が特定されることはありません。

✓分析結果は匿名化した後、学術雑誌や学会などで公表する予定です。また、【調査場所名】においても成果をまとめたリーフレットを配付致します。

✓本調査へのご回答は自由です。また、いかなる理由によってでも、途中で回答を中止していただくことが可能です。

✓本調査の実施に当たり、総合研究大学院大学における「人間を対象とする研究に関する倫理委員会」の承認（承認番号：2013004）、および、【調査場所名】のご協力を受けています。

以上の点をご理解の上、同意していただける場合は、別紙の質問へのご回答をよろしくお願い致します（所要時間は15分程度です）。

ご夫婦それぞれで回答していただいた後、質問紙を返信用封筒に入れ封の上、2014年2月10日までに郵便ポストに投函して下さい。ご回答いただいたアンケート用紙は適切に保管・使用致します。

期限までに質問紙を返送していただいた方々には、薄謝をお渡し致します。詳しくは別紙をご参照下さい。

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結婚・出産・子育てに関するアンケート調査

お子さんが2人の方

母 親 用

※ご夫婦で話し合わず、自分自身が思ったことを記入して下さい。

　ご記入が終わりましたら、旦那様の質問紙と一緒に専用の封筒に入れ封をしていただき、2014年2月10日までに郵便ポストに投函して下さい。

実施者：森田 理仁（大学院生）　責任者：長谷川 眞理子（教授）
国立大学法人 総合研究大学院大学　先導科学研究科 生命共生体進化学専攻
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[W1] 同居しているご家族について、あなたとの続柄、性別、年齢を教えて下さい。

続柄	性別	年齢
あなた	□ 男　☑ 女	(　　) 歳
配偶者	☑ 男　□ 女	(　　) 歳
お子さん1	□ 男　□ 女	(　　) 歳
お子さん2	□ 男　□ 女	(　　) 歳
(　　)	□ 男　□ 女	(　　) 歳
(　　)	□ 男　□ 女	(　　) 歳
(　　)	□ 男　□ 女	(　　) 歳
(　　)	□ 男　□ 女	(　　) 歳
(　　)	□ 男　□ 女	(　　) 歳
(　　)	□ 男　□ 女	(　　) 歳

[W2] あなたは現在、妊娠していますか。（当てはまる方に✓をして下さい）

□　はい	□　いいえ

[1] あなたの出身国を教えて下さい。（当てはまる方に✓をして下さい）

□　日本	□　日本以外

[2] あなたが配偶者と結婚した年齢を教えて下さい。

□ 歳

[3] あなたは離婚、もしくは配偶者と死別したことがありますか。
（当てはまる方に✓をして下さい）

□ はい	□ いいえ

[4] あなたの兄弟姉妹の人数（あなた自身を含める）を教えて下さい。

□ 人

[5] あなたの最終学歴を教えて下さい。
（当てはまるもの一つに✓をして下さい）

□ 中学校　□ 高校　□ 短大・専門学校　□ 大学　□ 大学院

[6] あなたは現在、仕事に就いていますか。
（当てはまるもの一つに✓をして下さい）

□ 有職　□ 休職中　□ 無職（学生・専業主婦を含む）

[7] あなたの昨年一年間の収入（税込）を教えて下さい。
（当てはまるもの一つに✓をして下さい）

□ なし　□ 200万円未満　□ 200万円以上、400万円未満
□ 400万円以上、600万円未満　□ 600万円以上、800万円未満
□ 800万円以上、1000万円未満　□ 1000万円以上

[8] 世帯全体の昨年一年間の収入（税込）を教えて下さい。
（当てはまるもの一つに✓をして下さい）

□ なし　□ 200万円未満　□ 200万円以上、400万円未満
□ 400万円以上、600万円未満　□ 600万円以上、800万円未満
□ 800万円以上、1000万円未満　□ 1000万円以上
□ 1500万円以上　□ わからない

子どもの人数について、お聞きします。
（最も当てはまる数字を一つ記入して下さい）

[9] 自分自身にとって、望ましい子どもの数は何人ですか。

□ 人　　□ わからない

[10] [9]でそのように答えた理由を教えて下さい。

（　　）

[11] 配偶者が思うだろう、望ましい子どもの数は何人だと思いますか。

□ 人　　□ わからない

[12] あなたの両親が思うだろう、望ましい子どもの数は何人だと思いますか。

□ 人　　□ わからない

[13] 配偶者の両親が思うだろう、望ましい子どもの数は何人だと思いますか。

□ 人　　□ わからない

[14] お子さんにとって、望ましい兄弟姉妹の数は何人だと思いますか。
（子どもの合計人数）

□ 人　　□ わからない

[15] 世間にとって、望ましい子どもの数は何人だと思いますか。
（夫婦一組当たりの子どもの数）

□ 人　　□ わからない

[16] 将来、あなたのお子さんがもつ子どもの数として、あなたが望ましいと思うのは何人ですか。

□ 人　　□ わからない

何人の子どもをもつかについて、あなたの判断に影響を与えた人物や出来事について、教えて下さい。（最も当てはまるもの一つに✓をして下さい）

[17] 自分の両親

□ まったく影響を受けなかった	□ あまり影響を受けなかった
□ 少し影響を受けた	□ 強く影響を受けた

[18] 配偶者の両親

□ まったく影響を受けなかった	□ あまり影響を受けなかった
□ 少し影響を受けた	□ 強く影響を受けた

[19] 自分と配偶者の両親以外の身内

□ まったく影響を受けなかった	□ あまり影響を受けなかった
□ 少し影響を受けた	□ 強く影響を受けた

[20] 友人

□ まったく影響を受けなかった	□ あまり影響を受けなかった
□ 少し影響を受けた	□ 強く影響を受けた

[21] 芸能人やマスコミ

□ まったく影響を受けなかった	□ あまり影響を受けなかった
□ 少し影響を受けた	□ 強く影響を受けた

[22] 世間の風潮

□ まったく影響を受けなかった	□ あまり影響を受けなかった
□ 少し影響を受けた	□ 強く影響を受けた

[23] その他に影響を受けた人物や出来事があれば、教えて下さい。

（　　）

結婚当初の、子どもをもつことに対する意識について、お聞きします。

[24] 結婚時すでに、あなたは妊娠、もしくは出産していましたか。

□ はい	□ いいえ

[25] [24]で「いいえ」と答えた方へ：子どもをもつことに対する結婚当初のあなたの希望として、最も当てはまるもの一つに✓をして下さい。

□ すぐにもとうと思っていた

□ しばらくしてからもとうと思っていた

□ もとうと思っていなかった

女性の出産について、お聞きします。
（最も当てはまる数字を一つ記入して下さい）

[26] 女性は何歳まで、母子ともに安全な状態で出産できると思いますか。

□ 歳まで　　□ わからない

[27] 女性はすべての環境が整えば、十分な子育てが可能な範囲内で、一生のうちに最大で何人の子どもを産むことができると思いますか。

□ 人　　□ わからない

１人目のお子さんについて、お聞きします。

[b1] 1人目のお子さんが生まれる前に、あなたが欲しいと思っていた子どもの人数を教えて下さい。（当てはまる数字を一つ記入して下さい）

□ 人　　□ 欲しいと思っていなかった

[b2] 1人目のお子さんが生まれる前、子どもが欲しいと思っていた方へ：性別の希望はありましたか。
（当てはまる方に✓をし、具体的な数字を記入して下さい）

□ はい（男：□ 人　／　女：□ 人）

□ いいえ

[b3] 1人目のお子さんをもつことに対して、あなたと配偶者のどちらが積極的でしたか。（最も当てはまるもの一つに✓をして下さい）

□ あなたのみが積極的だった

□ 双方が積極的だったが、あなたがより積極的だった

□ 双方が等しく積極的だった

□ 双方が積極的だったが、配偶者がより積極的だった

□ 配偶者のみが積極的だった

□ 双方が積極的ではなかった

[b4] 1人目のお子さんをもつことに対して、あなたと配偶者のどちらの希望が重視されましたか。（最も当てはまるもの一つに✓をして下さい）

□ あなたの希望のみで決まった

□ 双方の希望だが、あなたの希望がより重視された

□ 双方の希望が等しく重視された

□ 双方の希望だが、配偶者の希望がより重視された

□ 配偶者の希望のみで決まった

□ 双方が希望していなかった

[b5] 1人目のお子さんをもつことに至ったきっかけとして、どのようなことがありましたか。
（当てはまるものすべてに✓をし、具体的な内容があれば記入して下さい）

□ 生活が安定したから
(　　)
□ 子育ての環境が整備されたから
(　　)
□ 人的なサポートを得られたから
(　　)
□ 国や自治体の政策が整ったから
(　　)
□ 自分や配偶者の年齢を意識したから
(　　)
□ その他
(　　)
□ 特にきっかけはない

[b6] 1人のお子さんを育てていた時、お子さんがいなかった時と比べて、あなたは何を感じていましたか。（当てはまるものすべてに✓をして下さい）

□ 夫婦の絆の強化	□ 子育ての喜び	□ 仕事のやりがい
□ 精神的な充実	□ 生活のメリハリ	□ 老後の安心
□ 親になった満足感	□ 時間的な負担	□ 経済的な負担
□ 身体的な負担	□ 精神的な負担	□ 仕事が充実しない
□ 趣味が充実しない	□ その他（下に具体的に記入して下さい）	
(		)

[b7] あなたは、1人目のお子さんの出産や育児を理由に、仕事を退職しましたか。（当てはまるもの一つに✓をして下さい）

□ 仕事をしていて退職した（転職は含まない）

□ 仕事をしていて退職しなかった

□ 仕事をしていなかった

[b8] 1人目のお子さんが生まれる前と後（2人目のお子さんが生まれる前）で、あなたが自由に使える時間は変化しましたか。
（当てはまるもの一つに✓をして下さい）

□ 増加した	□ 減少した	□ 変わらない

[b9] 1人目のお子さんが生まれた後（2人目のお子さんが生まれる前）で、あなたがさらに欲しいと思っていた子どもの人数を教えて下さい。
（当てはまる数字を一つ記入して下さい）

□ 人　　□ さらに欲しいと思っていなかった

[b10] 1人目のお子さんが生まれた後（2人目のお子さんが生まれる前）、さらに子どもを欲しいと思っていた方へ：性別の希望はありましたか。
（当てはまる方に✓をし、具体的な数字を記入して下さい）

□ はい（男：□ 人　／　女：□ 人）

□ いいえ

2人目のお子さんについて、お聞きします。

[b11] 2人目のお子さんをもつことに対して、あなたと配偶者のどちらが積極的でしたか。（最も当てはまるもの一つに✓をして下さい）

□ あなたのみが積極的だった

□ 双方が積極的だったが、あなたがより積極的だった

□ 双方が等しく積極的だった

□ 双方が積極的だったが、配偶者がより積極的だった

□ 配偶者のみが積極的だった

□ 双方が積極的ではなかった

[b12] 2人目のお子さんをもつことに対して、あなたと配偶者のどちらの希望が重視されましたか。（最も当てはまるもの一つに✓をして下さい）

□ あなたの希望のみで決まった

□ 双方の希望だが、あなたの希望がより重視された

□ 双方の希望が等しく重視された

□ 双方の希望だが、配偶者の希望がより重視された

□ 配偶者の希望のみで決まった

□ 双方が希望していなかった

[b13] 2人目のお子さんをもつことに至ったきっかけとして、どのようなことがありましたか。
（当てはまるものすべてに✓をし、具体的な内容があれば記入して下さい）

□ 生活が安定したから
(　　)
□ 子育ての環境が整備されたから
(　　)
□ 人的なサポートを得られたから
(　　)
□ 国や自治体の政策が整ったから
(　　)
□ 自分や配偶者の年齢を意識したから
(　　)
□ その他
(　　)
□ 特にきっかけはない

[b14] 2人のお子さんを育てている現在、お子さんが1人の時と比べて、あなたは何を感じていますか。（当てはまるものすべてに✓をして下さい）

□ 夫婦の絆の強化	□ 子育ての喜び	□ 仕事のやりがい
□ 精神的な充実	□ 生活のメリハリ	□ 老後の安心
□ 親になった満足感	□ 時間的な負担	□ 経済的な負担
□ 身体的な負担	□ 精神的な負担	□ 仕事が充実しない
□ 趣味が充実しない	□ その他（下に具体的に記入して下さい）	

(　　)

[b15] あなたは、2人目のお子さんの出産や育児を理由に、仕事を退職しましたか。（当てはまるもの一つに✓をして下さい）

□ 仕事をしていて退職した（転職は含まない）

□ 仕事をしていて退職しなかった

□ 仕事をしていなかった

[b16] 1人目のお子さんが生まれてから、2人目のお子さんが生まれる前と後で、あなたが自由に使える時間は変化しましたか。
（当てはまるもの一つに✓をして下さい）

□ 増加した　　□ 減少した　　□ 変わらない

[b17] 2人目のお子さんが生まれた現在、あなたがさらに欲しいと思っている子どもの人数を教えて下さい。（当てはまる数字を一つ記入して下さい）

[　] 人　　□ さらに欲しいと思っていない

[b18] [b17]でそのように答えた理由を教えて下さい。

（　　）

[b19] 2人目のお子さんが生まれた現在、さらに子どもを欲しいと思っている方へ：性別の希望はありますか。
（当てはまる方に✓をし、具体的な数字を記入して下さい）

□ はい（男：　　人　／　女：　　人）

□ いいえ

以下の状況を想像して、お答え下さい。

[28] 現在、もしお子さんが1人もいなかったとしたら、あなたは何を感じると思いますか。（当てはまるものすべてに✓をして下さい）

□ 時間的な余裕　□ 経済的な余裕　□ 身体的な余裕

□ 精神的な余裕　□ 仕事のやりがい　□ 趣味の充実

□ 精神的な虚しさ　□ 老後の不安

□ 子どもをもつことへの焦り

□ その他（下に具体的に記入して下さい）

(　　)

[29] 現在、もしお子さんがさらに増えたとしたら、あなたは何を感じると思いますか。（当てはまるものすべてに✓をして下さい）

□ 夫婦の絆の強化　□ 子育ての喜び　□ 仕事のやりがい

□ 精神的な充実　□ 生活のメリハリ　□ 老後の安心

□ 親になった満足感　□ 時間的な負担　□ 経済的な負担

□ 身体的な負担　□ 精神的な負担　□ 仕事が充実しない

□ 趣味が充実しない　□ その他（下に具体的に記入して下さい）

(　　)

[30] もし将来、あなたは望んでいないのに、配偶者がさらに子どもをもちたいと望んだら、どうしますか。
（最も当てはまるもの一つに✓をして下さい）

□ あなたの希望を強く主張する

□ 配偶者の希望を尊重する

□ 夫婦でよく話し合って結論を出す

質問は以上です。ご協力いただき、どうもありがとうございました。最後に、結婚・出産・子育てについて思われること、もしくはこのアンケート調査についての感想やコメントなどがございましたら、ご自由にお書きいただけると嬉しく思います。

②

結婚・出産・子育てに関するアンケート調査

お子さんが2人の方

父 親 用

※ご夫婦で話し合わず、自分自身が思ったことを記入して下さい。

ご記入が終わりましたら、奥様の質問紙と一緒に専用の封筒に入れ封をしていただき、2014年2月10日までに郵便ポストに投函して下さい。

実施者：森田 理仁（大学院生）　責任者：長谷川 眞理子（教授）
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電話・FAX：046-858-1563 ／ E-mail：hasegawa_mariko@soken.ac.jp

[1] あなたの出身国を教えて下さい。（当てはまる方に✓をして下さい）

□　日本	□　日本以外

[2] あなたが配偶者と結婚した年齢を教えて下さい。

□ 歳

[3] あなたは離婚、もしくは配偶者と死別したことがありますか。
（当てはまる方に✓をして下さい）

□ はい	□ いいえ

[4] あなたの兄弟姉妹の人数（あなた自身を含める）を教えて下さい。

□ 人

[5] あなたの最終学歴を教えて下さい。
（当てはまるもの一つに✓をして下さい）

□ 中学校　□ 高校　□ 短大・専門学校　□ 大学　□ 大学院

[6] あなたは現在、仕事に就いていますか。
（当てはまるもの一つに✓をして下さい）

□ 有職　□ 休職中　□ 無職（学生・専業主夫を含む）

[7] あなたの昨年一年間の収入（税込）を教えて下さい。
（当てはまるもの一つに✓をして下さい）

□ なし　□ 200万円未満　□ 200万円以上、400万円未満
□ 400万円以上、600万円未満　□ 600万円以上、800万円未満
□ 800万円以上、1000万円未満　□ 1000万円以上

[8] 世帯全体の昨年一年間の収入（税込）を教えて下さい。
（当てはまるもの一つに✓をして下さい）

□ なし　□ 200万円未満　□ 200万円以上、400万円未満
□ 400万円以上、600万円未満　□ 600万円以上、800万円未満
□ 800万円以上、1000万円未満　□ 1000万円以上
□ 1500万円以上　□ わからない

子どもの人数について、お聞きします。
（最も当てはまる数字を一つ記入して下さい）

[9] 自分自身にとって、望ましい子どもの数は何人ですか。

□ 人　　□ わからない

[10] [9]でそのように答えた理由を教えて下さい。

（　　）

[11] 配偶者が思うだろう、望ましい子どもの数は何人だと思いますか。

□ 人　　□ わからない

[12] あなたの両親が思うだろう、望ましい子どもの数は何人だと思いますか。

□ 人　　□ わからない

[13] 配偶者の両親が思うだろう、望ましい子どもの数は何人だと思いますか。

□ 人　　□ わからない

[14] お子さんにとって、望ましい兄弟姉妹の数は何人だと思いますか。
（子どもの合計人数）

□ 人　　□ わからない

[15] 世間にとって、望ましい子どもの数は何人だと思いますか。
（夫婦一組当たりの子どもの数）

□ 人　　□ わからない

[16] 将来、あなたのお子さんがもつ子どもの数として、あなたが望ましいと思うのは何人ですか。

□ 人　　□ わからない

何人の子どもをもつかについて、あなたの判断に影響を与えた人物や出来事について、教えて下さい。（最も当てはまるもの一つに✓をして下さい）

[17] 自分の両親

□ まったく影響を受けなかった	□ あまり影響を受けなかった
□ 少し影響を受けた	□ 強く影響を受けた

[18] 配偶者の両親

□ まったく影響を受けなかった	□ あまり影響を受けなかった
□ 少し影響を受けた	□ 強く影響を受けた

[19] 自分と配偶者の両親以外の身内

□ まったく影響を受けなかった	□ あまり影響を受けなかった
□ 少し影響を受けた	□ 強く影響を受けた

[20] 友人

□ まったく影響を受けなかった	□ あまり影響を受けなかった
□ 少し影響を受けた	□ 強く影響を受けた

[21] 芸能人やマスコミ

□ まったく影響を受けなかった	□ あまり影響を受けなかった
□ 少し影響を受けた	□ 強く影響を受けた

[22] 世間の風潮

□ まったく影響を受けなかった　□ あまり影響を受けなかった

□ 少し影響を受けた　□ 強く影響を受けた

[23] その他に影響を受けた人物や出来事があれば、教えて下さい。

（　　）

結婚当初の、子どもをもつことに対する意識について、お聞きします。

[24] 結婚時すでに、配偶者は妊娠、もしくは出産していましたか。

□ はい　□ いいえ

[25] [24]で「いいえ」と答えた方へ：子どもをもつことに対する結婚当初のあなたの希望として、最も当てはまるもの一つに✓をして下さい。

□ すぐにもとうと思っていた

□ しばらくしてからもとうと思っていた

□ もとうと思っていなかった

女性の出産について、お聞きします。
（最も当てはまる数字を一つ記入して下さい）

[26] 女性は何歳まで、母子ともに安全な状態で出産できると思いますか。

□ 歳まで　　□ わからない

[27] 女性はすべての環境が整えば、十分な子育てが可能な範囲内で、一生のうちに最大で何人の子どもを産むことができると思いますか。

□ 人　　□ わからない

１人目のお子さんについて、お聞きします。

[b1] 1人目のお子さんが生まれる前に、あなたが欲しいと思っていた子どもの人数を教えて下さい。（当てはまる数字を一つ記入して下さい）

□ 人　　□ 欲しいと思っていなかった

[b2] 1人目のお子さんが生まれる前、子どもが欲しいと思っていた方へ：性別の希望はありましたか。
（当てはまる方に✓をし、具体的な数字を記入して下さい）

□ はい（男：□ 人　／　女：□ 人）

□ いいえ

[b3] 1人目のお子さんをもつことに対して、あなたと配偶者のどちらが積極的でしたか。（最も当てはまるもの一つに✓をして下さい）

□ あなたのみが積極的だった

□ 双方が積極的だったが、あなたがより積極的だった

□ 双方が等しく積極的だった

□ 双方が積極的だったが、配偶者がより積極的だった

□ 配偶者のみが積極的だった

□ 双方が積極的ではなかった

[b4] 1人目のお子さんをもつことに対して、あなたと配偶者のどちらの希望が重視されましたか。（最も当てはまるもの一つに✓をして下さい）

□ あなたの希望のみで決まった

□ 双方の希望だが、あなたの希望がより重視された

□ 双方の希望が等しく重視された

□ 双方の希望だが、配偶者の希望がより重視された

□ 配偶者の希望のみで決まった

□ 双方が希望していなかった

[b5] 1人目のお子さんをもつことに至ったきっかけとして、どのようなことがありましたか。
（当てはまるものすべてに✓をし、具体的な内容があれば記入して下さい）

□ 生活が安定したから
(　　)
□ 子育ての環境が整備されたから
(　　)
□ 人的なサポートを得られたから
(　　)
□ 国や自治体の政策が整ったから
(　　)
□ 自分や配偶者の年齢を意識したから
(　　)
□ その他
(　　)
□ 特にきっかけはない

[b6] 1人のお子さんを育てていた時、お子さんがいなかった時と比べて、あなたは何を感じていましたか。（当てはまるものすべてに✓をして下さい）

□ 夫婦の絆の強化	□ 子育ての喜び	□ 仕事のやりがい
□ 精神的な充実	□ 生活のメリハリ	□ 老後の安心
□ 親になった満足感	□ 時間的な負担	□ 経済的な負担
□ 身体的な負担	□ 精神的な負担	□ 仕事が充実しない
□ 趣味が充実しない	□ その他（下に具体的に記入して下さい）	
(		)

[b7] あなたは、1人目のお子さんの出産や育児を理由に、仕事を退職しましたか。（当てはまるもの一つに✓をして下さい）

□ 仕事をしていて退職した（転職は含まない）

□ 仕事をしていて退職しなかった

□ 仕事をしていなかった

[b8] 1人目のお子さんが生まれる前と後（2人目のお子さんが生まれる前）で、あなたが自由に使える時間は変化しましたか。
（当てはまるもの一つに✓をして下さい）

□ 増加した	□ 減少した	□ 変わらない

[b9] 1人目のお子さんが生まれた後（2人目のお子さんが生まれる前）で、あなたがさらに欲しいと思っていた子どもの人数を教えて下さい。
（当てはまる数字を一つ記入して下さい）

□ 人　　□ さらに欲しいと思っていなかった

[b10] 1人目のお子さんが生まれた後（2人目のお子さんが生まれる前）、さらに子どもを欲しいと思っていた方へ：性別の希望はありましたか。
（当てはまる方に✓をし、具体的な数字を記入して下さい）

□ はい（男：□ 人　／　女：□ 人）

□ いいえ

2人目のお子さんについて、お聞きします。

[b11] 2人目のお子さんをもつことに対して、あなたと配偶者のどちらが積極的でしたか。（最も当てはまるもの一つに✓をして下さい）

□ あなたのみが積極的だった

□ 双方が積極的だったが、あなたがより積極的だった

□ 双方が等しく積極的だった

□ 双方が積極的だったが、配偶者がより積極的だった

□ 配偶者のみが積極的だった

□ 双方が積極的ではなかった

[b12] 2人目のお子さんをもつことに対して、あなたと配偶者のどちらの希望が重視されましたか。（最も当てはまるもの一つに✓をして下さい）

□ あなたの希望のみで決まった

□ 双方の希望だが、あなたの希望がより重視された

□ 双方の希望が等しく重視された

□ 双方の希望だが、配偶者の希望がより重視された

□ 配偶者の希望のみで決まった

□ 双方が希望していなかった

[b13] 2人目のお子さんをもつことに至ったきっかけとして、どのようなことがありましたか。
（当てはまるものすべてに✓をし、具体的な内容があれば記入して下さい）

□ 生活が安定したから
(　　)
□ 子育ての環境が整備されたから
(　　)
□ 人的なサポートを得られたから
(　　)
□ 国や自治体の政策が整ったから
(　　)
□ 自分や配偶者の年齢を意識したから
(　　)
□ その他
(　　)
□ 特にきっかけはない

[b14] 2人のお子さんを育てている現在、お子さんが1人の時と比べて、あなたは何を感じていますか。（当てはまるものすべてに✓をして下さい）

□ 夫婦の絆の強化	□ 子育ての喜び	□ 仕事のやりがい
□ 精神的な充実	□ 生活のメリハリ	□ 老後の安心
□ 親になった満足感	□ 時間的な負担	□ 経済的な負担
□ 身体的な負担	□ 精神的な負担	□ 仕事が充実しない
□ 趣味が充実しない	□ その他（下に具体的に記入して下さい）	

(　　)

[b15] あなたは、2人目のお子さんの出産や育児を理由に、仕事を退職しましたか。（当てはまるもの一つに✓をして下さい）

□ 仕事をしていて退職した（転職は含まない）

□ 仕事をしていて退職しなかった

□ 仕事をしていなかった

[b16] 1人目のお子さんが生まれてから、2人目のお子さんが生まれる前と後で、あなたが自由に使える時間は変化しましたか。
（当てはまるもの一つに✓をして下さい）

□ 増加した　□ 減少した　□ 変わらない

[b17] 2人目のお子さんが生まれた現在、あなたがさらに欲しいと思っている子どもの人数を教えて下さい。（当てはまる数字を一つ記入して下さい）

[　] 人　□ さらに欲しいと思っていない

[b18] [b17]でそのように答えた理由を教えて下さい。

（　　）

[b19] 2人目のお子さんが生まれた現在、さらに子どもを欲しいと思っている方へ：性別の希望はありますか。
（当てはまる方に✓をし、具体的な数字を記入して下さい）

□ はい（男：　　人　／　女：　　人）

□ いいえ

以下の状況を想像して、お答え下さい。

[28] 現在、もしお子さんが1人もいなかったとしたら、あなたは何を感じると思いますか。（当てはまるものすべてに✓をして下さい）

□ 時間的な余裕　□ 経済的な余裕　□ 身体的な余裕

□ 精神的な余裕　□ 仕事のやりがい　□ 趣味の充実

□ 精神的な虚しさ　□ 老後の不安

□ 子どもをもつことへの焦り

□ その他（下に具体的に記入して下さい）

(　　)

[29] 現在、もしお子さんがさらに増えたとしたら、あなたは何を感じると思いますか。（当てはまるものすべてに✓をして下さい）

□ 夫婦の絆の強化　□ 子育ての喜び　□ 仕事のやりがい

□ 精神的な充実　□ 生活のメリハリ　□ 老後の安心

□ 親になった満足感　□ 時間的な負担　□ 経済的な負担

□ 身体的な負担　□ 精神的な負担　□ 仕事が充実しない

□ 趣味が充実しない　□ その他（下に具体的に記入して下さい）

(　　)

[30] もし将来、あなたは望んでいないのに、配偶者がさらに子どもをもちたいと望んだら、どうしますか。
（最も当てはまるもの一つに✓をして下さい）

□ あなたの希望を強く主張する

□ 配偶者の希望を尊重する

□ 夫婦でよく話し合って結論を出す

質問は以上です。ご協力いただき、どうもありがとうございました。最後に、結婚・出産・子育てについて思われること、もしくはこのアンケート調査についての感想やコメントなどがございましたら、ご自由にお書きいただけると嬉しく思います。

謝礼について

✓2014年2月10日までに質問紙をご返送いただいた方々に対して、薄謝ではございますが、お一人当たり1,000円（ご夫婦で2,000円）分のQUOカードをお送り致します。

✓ご希望の方は、謝礼用封筒に住所とご夫婦両方のお名前（事務手続きの都合上、必ずご夫婦両方のお名前が必要です）を記入していただき、回答済みの質問紙と一緒に返信用封筒に入れてご返送下さい。

✓謝礼の発送は、2014年3月以降となりますので、予めご了承下さい。

✓いただいた個人情報は、謝礼の発送のためだけに適切に保管・使用致します。また、質問に対するご回答との結び付けは一切行いません。

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Appendix

角形３号の封筒に印刷

料金受取人払郵便

葉山局承認

11

差出有効期間
平成 26 年 2 月
15 日まで

切手は不要です

〒２４０-０１９０

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森田 理仁　行

アンケート調査　返信用封筒

ご記入が終わりましたら、ご夫婦の質問紙を一緒にこの封筒に入れ封をしていただき、2014 年 2 月 10 日までに郵便ポストに投函して下さい。

ポストに投函の前に、以下の点を改めてご確認下さい。

□ ご夫婦両方の質問紙が入っていますか
□ 謝礼用の封筒が入っていますか（希望される方のみ）
□ 謝礼用の封筒に、ご夫婦両方のお名前が書かれていますか

お子さんが 2 人の方用

Appendix

角形３号の封筒に印刷

料金別納
郵便

ご住所

お名前（奥様）

様

お名前（旦那様）

様

特定記録

折曲厳禁

アンケート調査　謝礼用封筒

※ご住所とご夫婦両方のお名前を記入して
いただき、返信用封筒に入れて下さい。

（差出人）
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