

Influences on communication about reproduction: the cultural evolution of low fertility[☆]

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Abstract

The cultural norms of traditional societies encourage behavior that is consistent with maximizing reproductive success but those of modern post-demographic transition societies do not. Newson et al (2005) proposed that this might be because interaction between kin is relatively less frequent in modern social networks. Assuming that people's evaluations of reproductive decisions are influenced by a desire to increase their inclusive fitness, they will be inclined to prefer their kin to make fitness-enhancing choices. Such a preference will encourage the emergence of pronatal cultural norms if social networks are dense with kin. Less pronatal norms will emerge if contact between kin makes up a small proportion of social interactions. This article reports evidence based on role-play studies that supports the assumption of the kin influence hypothesis that evaluations of reproductive decisions are influenced by a desire to increase inclusive fitness. It also presents a cultural evolutionary model demonstrating the long-term effect of declining kin interaction if people are more likely to encourage fitness-enhancing choices when interacting with their kin than with nonrelatives.

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1. Introduction

This article reports the results of a test of a key assumption of the “kin influence hypothesis” (Newson et al., 2005) that communications between kin are more likely than communications between non-kin to encourage behavior consistent with achieving reproductive success. Communication biased in this way would provide a means by which individuals can promote their inclusive fitness (Hamilton, 1964).

The kin influence hypothesis suggests that, for any single interaction between close kin, there is a probability that this promotion will cause an attitude or behavioral change in the participants and that this change will tend in the direction of

a more effective pursuit of reproductive success. Over many social interactions occurring over time in kinship-based networks, this mechanism can maintain pronatal cultural norms (i.e., norms that prescribe behavior consistent with maximizing reproductive success). But when interaction between kin is only a small proportion of social interaction, as in modern societies, cultural norms can evolve that allow behavior to become increasingly less consistent with the efficient conversion of resources to offspring. This mechanism could largely account for the demographic transition, the collapse in fertility that occurs as societies modernize (Borgerhoff Mulder, 1998).

We present a cultural evolutionary model demonstrating how a reduction in contact between kin could result in the erosion of pronatal cultural norms if the content of communication is biased in the way suggested by the kin influence hypothesis. Cultural evolutionary models have shown that even very weak innate biases influencing the transmission of information within a population will cause

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the cultural norms of that population to change. Over time and many social interactions, culture evolves in a way that can be predicted by the direction of the bias (Boyd & Richerson, 1985; Durham, 1991; Richerson & Boyd, 2005). Theoretical investigations of biased transmission have previously concentrated on “learning” biases of potential recipients of cultural information, which influence what learners adopt. The kin influence hypothesis assumes a “teaching” bias in the sources of cultural information. These influence the information available to learners.

2. Modernization, reproduction, and culture

2.1. Modern social networks and fertility

The pattern of social interactions that occurs in modern social networks is an evolutionary novelty. Living in kin-based social groups is a human characteristic with evolutionary roots that probably extend back to the Miocene (Foley, 1996). Compared to other ape societies, all human societies are remarkable in the extent to which cooperation occurs between nonrelatives (Richerson & Boyd, 2005). Nevertheless, traditional societies are highly kin-oriented, compared to modern societies. Industrialization introduces cheap mechanized transport and allows family members to pursue economic opportunities far from their place of birth. As a result, the vast majority of interactions occurring in postindustrial societies are between individuals who are not genetically related, and interactions that take place via contemporary telecommunication media are often between people who have not even met. That modernization is the trigger for a dramatic change in social networks has been well documented (e.g., Notestein, 1945; Ogburn & Nimkoff, 1955; Thornton & Frick, 1987; Zelinsky, 1971).

Links between a widening of social networks and the adoption of reproductive behavior that is inconsistent with maximizing reproductive success are also well documented. Individuals with wider social networks are the first in a population to adopt family limitation (e.g., Axinn & Barber, 2001; Axinn & Yabiku, 2001; Barber, Pearce, Chaudhury, Gurung, 2002; Behrman, Kohler, Watkins, 2002; Bongaarts & Watkins, 1996; Boulay & Valente, 1999; Kohler, 2001; Valente, Watkins, Jato, van de Straten, Tsitsol, 1997; Watkins, 1990; Watkins & Danzi, 1995; Weinstein, Sun, Chang, Freedman, 1990, Godley, 2001). Reproductive decisions that limit family size might be adaptive in environments in which resources are restricted (e.g., Mace, 1998), but the family limitation that accompanies modernization occurs at a time of rapid increase in the availability of resources. The norms of modern societies encourage parents to believe that they must invest large amounts of time and resources in their children if they are to be successful, but there is no evidence that this investment pays off in terms of reproductive success. Kaplan, Lancaster, Johnson, and Bock (1995) found that men raised in small

families did not achieve greater fitness than those raised in large families.

Turke (1989) has also suggested that the modern fertility decline may be the result of a reduction in contact between kin, suggesting that psychological mechanisms, which evolved to solve the problem of allocating life effort in a manner that maximizes reproductive success, monitor the availability of committed caregivers to provide help with raising children. When kin cease to be available, these mechanisms determine reproductive resources to be low, even if the couple is well supplied with physical resources. Therefore, instead of investing in a large number of offspring, couples concentrate their reproductive investment on producing small number of socially competitive children.

2.2. Culture and reproductive decisions

Newson et al. (2005) argue that, although the amount of practical support available from a kinship network may be one of the factors that influence reproductive decisions at the individual level, if viewed at the population level, kin altruism may have a more important effect.

Individuals operating in a social network provide each other with a vast amount of social information. A long tradition of research in social psychology has shown that the exchange of social information that occurs within a group creates and maintains the social norms or culture of the group (e.g., Turner, 1991; Postmes, Haslam & Swaab, 2005). Day-to-day discussions between group members develop and continually revise the canon of values and beliefs that provide the proximate explanations for many of the decisions, including reproductive decisions, that are made by group members. For example, the belief that each child needs his own bedroom will motivate a couple who can only afford a three-bedroom home to avoid having a third child. Reproductive decisions are influenced by many such cultural elements, and modern societies have developed a large number of elements that combine to make even very prosperous people believe they cannot or should not raise a large family.

The kin influence hypothesis does not suggest that kin obsessively encourage wise reproductive decisions or that people who are not related spitefully encourage behavior that reduces reproductive success. The bias is weak, so the content of conversations between both friends and relatives will largely reflect prevailing cultural norms. However, it has been seen that when social networks are dense with kin, cultural institutions encourage couples to produce as many children as they can successfully raise (Lorimer, 1954). For example, an explanation of why African societies may “offer greater resistance to fertility decline” (Caldwell & Caldwell, 1987, p. 409) summarizes cultural characteristics that acted (and, to some extent, still do act) to maintain high fertility. In interviews about childbearing conducted in Africa, a majority responded that it is “fearful” to die without children. Limiting of family size was considered extremely risky because of a keen awareness of the

possibility that all one's children might die. The rare cases of an entire family perishing were widely reported and long remembered. According to [Caldwell and Caldwell \(1987\)](#), these attitudes to reproduction were underpinned by remnants of ancient religious beliefs in which gods or ancestors were concerned with continuance of the family. High fertility was seen to be not only a divine reward but also evidence of correct behavior. People who did not have a son to perform the correct burial rituals become unhappy wandering ghosts. Thus, even if raising many sons was extremely costly in ecological terms, in cultural terms, the cost of not having a surviving son was incalculable.

In modern societies, in which social networks are largely made up of non-kin, the cultural institutions that encourage individuals to marry and have a family tend to be less strong and are becoming weaker (e.g., [Alstott, 2004](#); [Mack, 1997](#)), and the cultural rewards for successfully pursuing alternative goals, such as a career, are increasing.

2.3. *The cooperative nature of human reproduction*

Why do cultural institutions have such a strong influence on reproductive decisions? How could natural selection have allowed human decisions that are so vital to individual fitness be subject to cultural influence? As [Krebs & Dawkins \(1984\)](#) point out, if an animal's behavior can be influenced by competing conspecifics, it is vulnerable to manipulation. Theorists such as [Lumsden and Wilson \(1981\)](#) and [Tooby and Cosmides \(1992\)](#) have argued that evolved mechanisms must place constraints on the elements of culture that individuals adopt because selection would have favored individuals who resisted adopting cultural norms when doing so would inhibit the propagation of their genes.

The strength of cultural influence might be explained by the cooperative nature of human reproduction, which has several unusual features associated with mothers being able to co-opt help with the raising of their young ([Hill, 1993](#); [Hrdy, 1999](#); [Mace, 2000](#)). Like other great apes, humans give birth to offspring that are helpless, slow to mature, and require a great deal of parental care. But, while human infants are most extreme in this respect, human mothers are more prolific breeders than other apes. There is variation between cultures, but humans typically space births between 2.5 and 3.5 years apart, compared to 4 to 5 years for chimps and nearly 8 for orangutans. This results in human mothers having several children at different stages of dependency, a situation that is only possible if the mother receives help with caring for and provisioning her young. Human life history has evolved so that a source of help is available within human groups. Compared to other mammals, humans, especially human females, are reproductively active for a small portion of their lives. Members of the group who are in the pre- and postreproductive phase of their lives can and do help care for and socialize the children of women who are reproductively active ([Hawkes, O'Connell, Blurton-Jones, 1997](#); [Hrdy, 1999](#); [Mace, 2000](#)).

This allows them to enhance their inclusive fitness and form useful reciprocal altruism-based alliances.

In humans, therefore, the social network is a resource on which mothers depend to successfully raise their offspring, and this means that each reproductively active woman's decisions about the timing of her births affects the reproductive opportunities of her peers. A woman whose reproductive behavior resulted in the group devoting an unfair portion of their efforts to her offspring could be punished by social exclusion, or group members could simply provide less care for the offspring and, thus, reduce their chance of survival. Such policing activities inevitably damage groups, however. The greatest reproductive success would have been achieved by members of groups that developed ways of establishing a consensus on the reproductive behavior that was appropriate, given the resource levels available (for an analysis on how such prosocial behaviors could evolve when culture is a factor, see [Boyd & Richerson, 1985](#); [Boyd, Gintis, Bowles, Richerson, 2003](#); [Richerson & Boyd, 2001](#); [Richerson, Boyd, Henrich, 2003](#)).

It may be that as long as an individual's social group contains a substantial proportion of people who are interested in promoting each other's reproductive success, the consensus can be relied upon to prescribe behavior consistent with the maximization of inclusive fitness. Indeed, observations of traditional societies by a number of human behavioral ecologists revealed that the reproductive norms of these societies encourage behavior that is indistinguishable from that which individuals would choose if striving to maximize their inclusive fitness (e.g., [Chagnon, 1988](#); [Hill & Hurtado, 1996](#); [Borgerhoff Mulder, 1988](#); [Cronk, 1989](#); [Irons, 1979](#); [Wang, Lee, Campbell, 1995](#); and reviews by [Cronk, 1991](#), [Volland, 1998](#), and [Low, 1993, 1999, 2000](#)).

But when groups are largely made up of unrelated individuals, with no interest in each other's fitness, the consensus reached may reflect other shared or individual goals.

2.4. *An interweaving of social instincts*

[Richerson and Boyd \(2001\)](#) suggest that human behavioral decisions are influenced by two sets of "social instincts." One is a set which humans share with other apes. These incline them to compete with other members of their social group. The other set of social instincts is more recently evolved and unique to humans. These incline individuals to cooperate with their fellow group members. The way competition and cooperation are interwoven can be observed in every aspect of human behavior. For example, when a modern father heavily invests in his daughter to ensure she gets a good education, he is partly motivated by competition: he desires that she will be successful relative to her peers. But he is also behaving cooperatively in the sense that he has adopted the modern system of social norms that highly values economic success. The man's fitness would be better served by

having more children and encouraging them to begin childbearing early (Kaplan et al., 1995).

The kin influence hypothesis assumes that the interweaving of cooperation and competition influences people as they transmit the social communications that maintain cultural norms and values. It also assumes that genetic self-interest is a factor in the competitive strand. Parents would like their children to be healthy, happy and successful in the terms of their shared culture—but they would also like some grandchildren. Thus, when a modern woman talks to her daughter about future plans, cultural norms will incline her to be concerned for her daughter's happiness and career success, but in most cases, her daughter's reproductive plans will also be salient, more salient than they would be during a similar conversation with younger friend, work colleague, or student.

3. The influence of kinship on the evaluation of reproductive decisions

The suggestion that mothers want their children to “give them grandchildren” may be in accord with common experience, but it is not a trivial task to detect differences in communication about reproduction that pass between kin and non-kin. It would be impossible, not to say unethical, to accurately sample the myriad private social interactions which reflect, but also maintain and modify, the cultural norms regarding reproduction and other life ambitions.

To test whether kinship influences a woman's judgment on reproductive decisions, we used a passive role-play technique. Our aim was to determine if women receiving a scenario asking them to play the role of “mother” were more likely to respond with encouragement of behavioral choices that are more consistent with achieving reproductive success, including in situations in which not having a baby would be more consistent with achieving reproductive success.

3.1. Method

We asked female participants to read one of 16 scenarios of 600–800 words, which depicted a childless woman of reproductive age (called “Nicola”) asking an older woman (called “Barbara”) if, given her situation, she should have a baby. We then asked the participants (1) to write down what they think Barbara will say to Nicola and (2) what they themselves think Nicola should do.

In 8 of the 16 scenarios, Barbara and Nicola are depicted as being mother and daughter, and in the other eight, they are depicted as being close friends who are a generation apart in age. In all the scenarios, “Barbara” is depicted as being a happily married, financially secure homeowner with an adult child. Nicola's situation varies. In eight of the scenarios, she is depicted as being in her early 20s, and in the other eight, she is depicted as being in her early 30s. Her personal circumstances are depicted in four different ways:

1. “Career couple”: Nicola and her husband both have successful careers and are supremely happy as a childless couple. Nicola had imagined that she would have a child one day but now she is not sure if she wants a baby. She is worried that the disruption wrought by the introduction of a new family member will jeopardize the excellent relationship and carefree fun that she and her husband enjoy.
2. “Stepmother”: Nicola is the stepmother of two school-age boys from her husband's previous marriage. Her husband and his sons were abandoned by his ex-wife. Nicola and her husband would like to have children of their own and can afford more children, but they are worried that the boys, who are still getting used to having Nicola as a stepmother, will feel threatened by an addition to their family.
3. “Widow”: Nicola married her boyfriend when he was discovered to have a terminal brain tumor. She now feels she would like to have his baby “to keep a part of him alive and with me.”
4. “Single woman”: Nicola has a successful career, but she has no steady partner, and she feels she doesn't want or need a man in her life. She would like a child, however, and is considering having a child and raising him on her own.

Texts of the scenarios and questions asked of participants can be viewed on http://psychology.ex.ac.uk/archive/In202/newson2007e_hb_scenarios.pdf.

3.1.1. Design

The variations in the 16 scenarios created four dichotomous independent variables, which might influence participants' opinion on whether Nicola should get pregnant:

- Situation (easy or difficult): in the career couple and stepmother stories, Nicola's circumstances present no practical difficulties for the raising of children. She is financially secure and has a supportive husband. These scenarios therefore depict relatively easy situations for raising a child. The widow and single woman situation depict more difficult situations because the child's father will not be present to help Nicola as her child grows up.
- Norms (normal or deviant): in the widow and single woman, Nicola's situation for raising a child is almost identical in practical terms. She will be raising the child as a single parent. Having a baby in the single woman scenario is more likely to be considered deviant, however, because Nicola is proposing raising a child who will not have a socially acknowledged father.
- Relationship (mother or friend): each of the four stories were told in two versions, depicting Barbara and Nicola as mother and daughter or as friends.
- Age (younger or older): each of the four stories were told in two versions, depicting Nicola as being in her

early 20s and, therefore, young enough to wait and get pregnant later, or in her early 30s, nearing the end of her reproductive years and, so, cannot delay too much longer or she will be at risk being unable to conceive a child.

The text written by participants in response to our request to write what they thought Barbara would say to Nicola provided two dependent ordinal variables with three values.

- “Answer”: did the response include the answer “yes” Nicola should start trying to become pregnant? (1); did it include the answer “no” she should not start trying to become pregnant? (–1); or did it not include any definite answer? (0)
- “Advice”: was the advice and information included in the response likely to sway a younger woman toward trying to become pregnant? (1) Away from trying to become pregnant? (–1) Or did it include no advice or neutral advice? (0)

Values were assigned to these variables by two female coders, one in her early 50s and the other in her mid 20s. Each coder first evaluated the replies independently and then met to compare and agree scores. The coders were blind to which scenario had generated each response, but since the responses usually contained information about Nicola’s situation, the coders were not completely blind.

Participants’ own opinion about what Nicola ought to do provided a third dependent variable:

- “Own belief”: After they had finished writing a reply on behalf of the “Barbara” character, participants were asked, “What do you yourself really think that Nicola ought to do?” They chose their response from a list of six, ranging from an unqualified positive (“Try for a baby now”) to an unqualified negative (“She definitely should not have a baby in this situation”). The six were collapsed into three ordinal values for the analysis.

To examine the influence of situation, whether Nicola is in an easy or difficult situation for raising a child, responses to the career couple and stepmother stories were compared with responses to the widow scenario.

To examine the influence of norms, whether becoming pregnant would be considered deviant, responses to the single woman stories were compared with responses to the widow scenario.

3.1.2. *The participants*

Participants were 379 women aged from 25 to >75 years, who were recruited from among University of Exeter staff and alumni through notices placed in libraries and on Web sites likely to attract women interested in such a study and through a newsletter e-mailed to listeners of the British Broadcasting Corporation radio program “Woman’s Hour.” Roughly two thirds of the participants were mothers.

Nearly 80% of the participants were from Britain, and the rest reported themselves as being from other developed countries. To perform the task, participants had to be fluent in English and use a computer connected to the Internet. They could therefore be considered culturally modern women. Potential participants were directed to a Web site which explained that the study would be about the choices that women face. Those who agreed to take part were randomly linked to 1 of 16 Web sites, which presented them with a scenario and collected their responses. Between 20 and 28 responses were collected for each scenario.

The participants were asked to supply information about their age and whether or not they themselves were mothers because it was thought this might provide some explanation for individual differences in responses.

3.1.3. *Predictions*

For modern women, the practicalities of raising a child will not necessarily be of prime importance when evaluating reproductive options because the affluence and welfare institutions of modern societies make it possible for women to raise children without the help of their father. However, raising a child in difficult circumstances can reduce overall reproductive success. The kin influence hypothesis predicts that women playing the mother role will be more likely than those in the friend role to be positive about pregnancy, when Nicola’s situation is one in which it is easy to raise a child and less likely to be positive when the situation is difficult. When becoming pregnant would also break a social norm, it is expected that both mothers and friends will be influenced by the norm to be less positive about pregnancy. The hypothesis predicts that age will also have an effect. When raising a child would be difficult or deviant, participants playing the role of mother will be more inclined to encourage pregnancy if they consider Nicola to be near the end of her reproductive life. In this case, waiting for the situation to improve would risk not being able to have a child at all.

3.1.4. *Analysis*

The responses were analyzed by ordinal regression, using the SPSS PLUM procedure to calculate effect sizes (parameter estimates), which can be used to calculate the odds of respondents giving a positive response in each of the three dependent variables. Ordinal regression is appropriate here because it does not require arbitrary numerical values to be assigned to ordinal levels, hence avoiding an analysis that turns on interpretation of artificial numerical quantities (McCullagh & Nelder, 1989). At the same time, however, ordinal regression provides an interpretation that is analogous to a single-regression model connecting dependent variable to predictors.

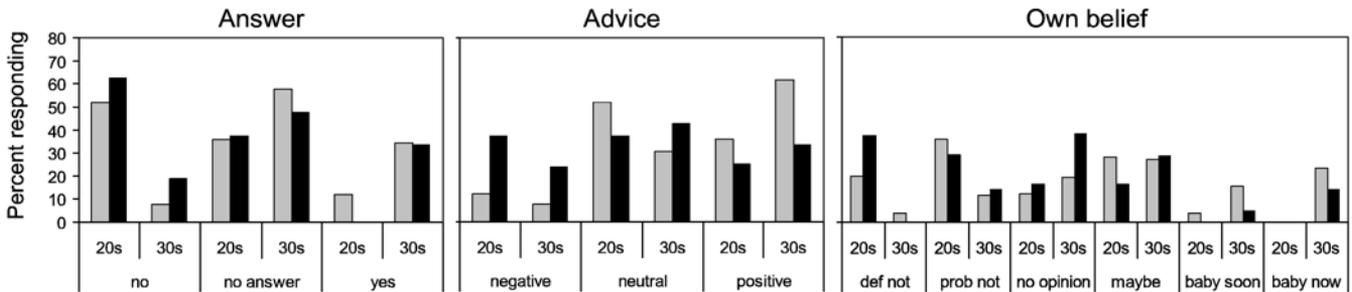
Separate models were used to test the effect of situation and norms. In each model, the independent variables relationship and age were included, along with each

possible two-way interaction and the interaction of all three variables.

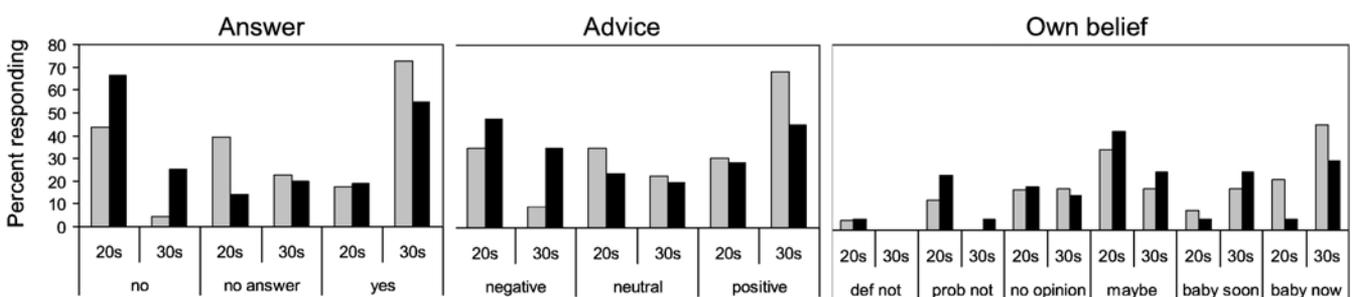
A key assumption of the ordinal regression model is that ratios comparing the odds of a response at or below a given level depend only on the covariate predictors and not on the

level of the dependent variable in question (McCullagh & Nelder, 1989). Models are tested to determine if each data set allows the assumptions to be met. To meet these assumptions, adjacent ordinal levels of the own belief variable were combined to create three levels. For the

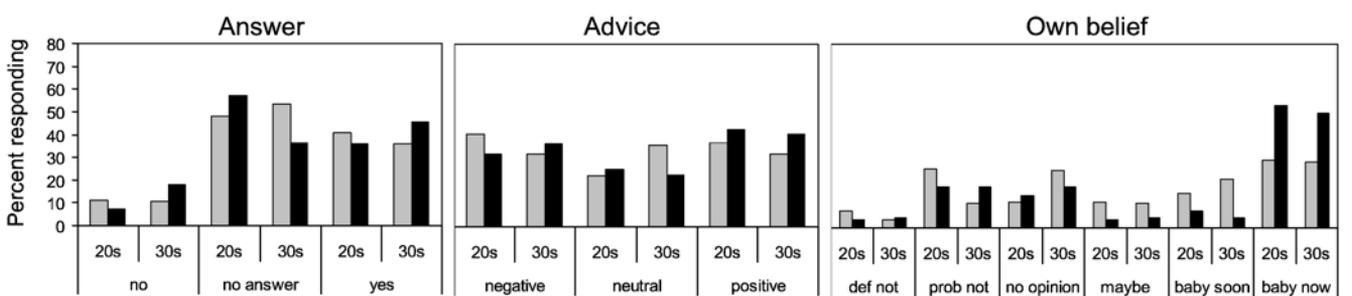
Career couple scenario



Stepmother scenario



Widow scenario



Single woman scenario

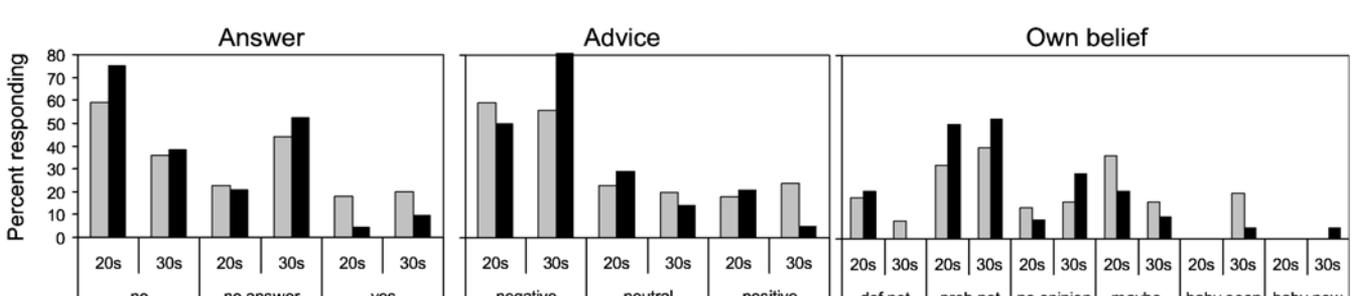


Fig. 1. Frequency of responses to scenarios. Responses of participants evaluating whether character should try to have a baby. Participants were assigned to mother or friend condition. The character's circumstances (one of four scenarios) and age (in early 20s or early 30s) were also manipulated.

situation model, the division compared an unqualified positive value with a neutral value consisting of conditionally positive, “don’t know” and “no opinion” and a negative value consisting of conditionally and unconditionally negative. For the norms model, the conditional and unconditional positive responses were compared to a neutral response consisting of don’t know, no opinion, and conditionally negative and a negative response consisting only of unconditionally negative.

3.2. Results

The tone and content of the responses participants gave when writing what they thought Barbara would say to Nicola provide ample evidence that the participants understood the scenario and wanted to express themselves clearly. Most of the answers were written in the first person and mentioned details from the scenario. Some replies also included accounts of personal experiences of the participant and evidence of emotional engagement. However, only a third of participants included an explicit answer to Nicola’s question when writing what they thought Barbara would reply. Many responses explicitly stated that it had to be Nicola’s (or Nicola and her husband’s) decision. However, over 90% did express a preference in the advice they wrote, in the statement of their own belief, or in both. The frequencies of the responses in the 16 conditions are displayed in Fig. 1.

Not surprisingly, there were correlations between the three dependent variables representing the response of the participants. What the respondent said was her own belief correlated more strongly with the answer in her written reply (Kendall’s tau-b=.455, $p < .001$) than the advice included (Kendall’s tau-b=.362, $p < .001$) in the written reply. Answer and advice were also correlated (Kendall’s tau-b=.474, $p < .001$). Whether or not the participant was a mother herself was found to be correlated with some of her responses and, so, was included in the model as a covariate. The age of the participants was not found to be correlated with any of the responses and, so, was not included. The advice participants wrote in their replies was not significantly correlated with any of the independent variables, but the answer included in their replies and their own beliefs stated afterwards were.

The model testing the association between responses and the situation for raising a child revealed a large effect of this variable (Table 1). Participants were more positive about pregnancy when Nicola was depicted as being in the “difficult” situation of wanting her dying husband’s child than when she is in the relatively “easy” situation of the career couple or the stepmother. They were 12 times as likely to include yes in their reply and 25 times as likely to say that they themselves thought Nicola should get pregnant. The age of the woman contemplating pregnancy also had an effect. Participants who received scenarios depicting Nicola as being in her 30s were over four times as likely to say yes to pregnancy and nearly eight times as likely to believe she should

Table 1

Parameter estimates (S.E.) for the ordinal regression models describing associations between participants’ responses and Nicola’s situation along with other covariates

	Answer	Advice	Own belief
Situation=difficult	2.45*** (.56)	.59 (.45)	3.25*** (.58)
Age=older	1.49** (.49)	.57 (.40)	2.04*** (.53)
Relationship=mother	.70 (.44)	.54 (.83)	.80 (.49)
Situation×relationship	-.24 (.71)	-.92 (.63)	-2.06** (.76)
Age×situation	-1.83* (.80)	-.68 (.66)	-2.16** (.79)
Age×relationship	.97 (.65)	.58 (.57)	-.42 (.67)
Situation×relationship×age	-1.28 (1.07)	-.32 (.92)	.73 (1.06)
Covariate: whether participant has children	.01 (.27)	.33 (.24)	.92** (.27)

* $p < .001$.

** $p < .01$.

*** $p < .05$.

get pregnant than those who received scenarios depicting her to be in her early twenties. The relationship depicted did not have a significant general effect on the participants’ responses. Whether or not the participant is a mother herself is associated with her own belief about Nicola’s choices. For any given combination of situation, e.g., age and relationship, those who do not have children themselves are more likely than mothers to think Nicola should get pregnant. The response pattern for the combination of age and situation revealed that participants were less likely to take age into account when the situation was difficult.

The combination of situation and relationship in the own belief variable reveals that when the situation for raising a child was difficult, participants who had played the role of mother were less likely to be positive about pregnancy than those who had played the role of “friend.” Under the proportional odds model, the natural logarithm of the odds of a neutral or negative response for combinations of independent variables is obtained by adding the appropriate parameter estimates and changing the sign (McCullagh & Nelder, 1989). In this case, 0.80 ± 2.06 yields an odds ratio estimate of $e^{1.24}$ or 3.56. The odds of a positive response then would be the reciprocal or 0.29. So, when the situation for raising a child was depicted as difficult, participants who had played the role of mother were about a quarter as likely as those who had played the role of friends to think the young women should get pregnant. By contrast, when the situation for raising a child was depicted as easy, those completing the task in the mother role were about twice as likely as friends to believe she should get pregnant.

The response pattern for the combination of age and situation revealed that participants were less likely to take age into account when the situation was difficult. When responding to the career couple and stepmother stories, women were more inclined to discourage a young Nicola from becoming pregnant than Nicola depicted as being in her 30s. This difference was not seen in those responding to the widow scenario.

The model testing the effect of norms on responses revealed that whether or not becoming pregnant would be considered deviant had a very large effect (Table 2). When

Table 2

Parameter estimates (S.E.) for the ordinal regression models describing associations between participants' responses and whether or not becoming pregnant would be considered deviant

	Answer	Advice	Own belief
Norm=deviant	-2.35** (.63)	-.82 (.52)	-2.01* (.58)
Age=older	-.32 (.62)	-.12 (.53)	-.21 (.58)
Relationship=mother	.37 (.56)	-.35 (.50)	-.46 (.55)
Norm×relationship	-.73 (.82)	.01 (.76)	1.07 (.80)
Age×norm	.77 (.88)	-1.35 (.86)	.71 (.83)
Age×relationship	-.23 (.84)	.23 (.73)	.52 (.79)
Norm×relationship×age	1.35 (1.22)	1.42 (1.15)	-.75 (1.1)
Covariate: whether participant has children	.57 (.33)	.31 (.30)	.34 (.31)

* $p < .01$.

** $p < .001$.

they had received a scenario depicting a woman wanting to have a child without the involvement of a socially acknowledged father, participants were a tenth as likely to say yes to pregnancy than when they had received the story depicting a woman contemplating widowhood. Recipients of the single woman scenario were 0.13 as likely to say they believed the woman should consider having a baby in her situation. No other independent variables or combinations were found to have a significant effect.

A more detailed report of the results, including the text of the responses, can be viewed on http://psychology.ex.ac.uk/archive/In202/newson2007e_hb_responses.pdf.

3.3. Discussion

Our aim was to investigate how specific changes in the framing of reproductive situations might affect a woman's evaluation of the options. The stories were designed to observe the effect that practical considerations and cultural norms have on a modern woman's belief about a reproductive decision and to detect if this is influenced by a preference for promoting the reproductive success of close kin.

Data supported one prediction of the kin influence hypothesis. Women primed by playing the mother role were more inclined to believe the Nicola character should get pregnant when she was in a good situation to raise a child and less inclined to believe she should get pregnant when raising a child would be difficult and, thus, likely to jeopardize her reproductive success in the longer term. The practicalities of child rearing were found to be of less concern when women were primed by playing the role of a friend. When Nicola was depicted as a woman wanting her dying husband's child, all the participants were largely sympathetic to her desire, but those in the friend condition were more likely to say they believed she should get pregnant.

This effect was seen in the own belief value, which was chosen by the participant herself after she had been primed by writing the response. This is likely to be the best indicator of the participant's opinion. In the answer or advice variables, the effect may have been diluted because many participants playing the role of mother invested a lot in expressing overt sympathy and support for Nicola's

desire to have a child when writing their response. But then, in response to the question of what they themselves believed, many said they did not think she should get pregnant. Of course, the nature of the design of this role-play setting limits the generalizability of these results to actual reproductive advice, but the design does allow us to conclude that specific changes in the framing of reproductive situations affect a woman's evaluation of the options in line with predictions of the kin influence hypothesis.

As expected, the norms and beliefs of these culturally modern women had a larger effect than practical concerns. The belief that a woman should not choose to have a baby without the involvement of an acknowledged father had a powerful effect on participants' opinions about what Nicola should do, and this was not detectably mitigated by the age or relationship depicted.

Another prediction generated by the hypothesis was neither supported nor refuted by the data—that the age depicted would influence the evaluations of those playing the role of mother so that they would be more positive about pregnancy in a bad context if “a daughter” was nearing the end of her reproductive life. This might be because contemporary beliefs about the age at which women can and should have children do not reflect biological realities. We had not anticipated that many participants would believe that a woman in her early 30s has plenty of time left in which to decide to have a baby. Yet, this appears to have been the case. The content of several responses included statements like “women give birth right into their 40s nowadays.” Nicola's age was found to have an effect in the model comparing easy and difficult situations for raising a child. Participants were more likely to recommend pregnancy when the Nicola character was depicted as being in her 30s. However, judging from the content of the replies, this was as much to do with a belief that a woman in her early 20s should postpone child-bearing until she has experienced more of life than a belief that a woman aged 33 years should not delay for fear of losing the chance of having children. When the situation for raising a child was depicted as being difficult because Nicola's husband did not have long to live, participants were more likely to encourage a 23-year-old Nicola to get pregnant immediately, undoubtedly because waiting would not be an option if she wanted her dying husband's child.

If humans are inclined to promote their inclusive fitness (Hamilton, 1964), there should be an innate bias to encourage kin to reproduce more when circumstances are favorable. This study provides convincing evidence for the existence of such a bias, but the effect of the preference is not large. People would prefer their kin to behave in fitness-enhancing ways, but as the kin influence hypothesis predicts, people's evaluation of a reproductive option largely reflect the beliefs, values, and norms extant at time the judgment is made. In the next section, however, we will show that, viewed on the population level and over time, the effect of even a small preference can be large.

4. The cultural evolution of low fertility

Boyd & Richerson (1985) (pp. 144–145) presented a very simple model of the effect of biased “teaching” on the direction of cultural change. We here develop a similar model to examine the implications of the existence of a kin bias and test the suggestion of the kin influence hypothesis that such a bias could lead to the widespread adoption of low-fertility norms even when natural selection opposes the cultural evolution of low fertility by favoring those who do not adopt family limitation.

Assume the life cycle diagrammed in Fig. 2. Consider a dichotomous cultural trait with two variants *h* for high fertility and *l* for low fertility. Consider two biased modeling effects, B_K a kin bias favoring *h* and B_N , a non-kin bias favoring *l*. Individuals who have themselves adopted the *h* variant have a decreased probability of transmitting that variant during non-kin interactions and an increased probability of transmitting the *l* variant. The parameter B_N measures the strength of this bias. Individuals have an elevated probability (measured by B_K) of transmitting the *h* variant during kin interactions even when they themselves have adopted the *l* variant.

For simplicity, assume that each adolescent is influenced by a closely related individual with a transmission weight of *A* and a non-relative with transmission weight of $(1-A)$, where the sum of the two weights is 1. Each adolescent samples a relative and nonrelative from the population at random. Table 3 sets out the scheme of socialization incorporating these assumptions. After adolescents are socialized by relatives and nonrelatives, they reproduce at rates that are subject to natural selection (*s*).

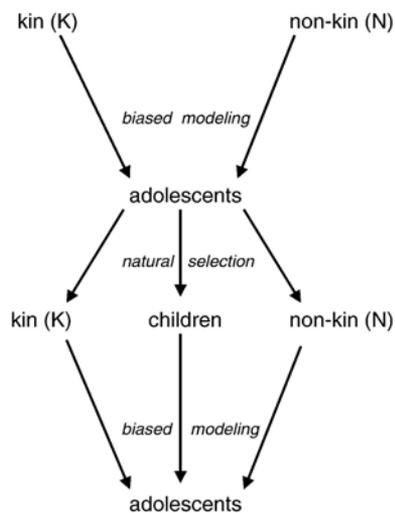


Fig. 2. Life cycle for biased modeling and selection. Biased modeling occurs in the transmission of fertility norms from parents and nonparents to adolescents. For example, during non-kin interactions, individuals with a high-fertility norm selectively model or teach the low-fertility norm such that imitators have a certain chance of acquiring the low-fertility norm from high-fertility non-kin. (See Table 3 for details.) Parents with high-fertility norms have more children than those who have low-fertility norms, so natural selection favors high-fertility norms.

Table 3
Cultural transmission table

Socializer is. . .		Probability adolescent is. . .	
Kin	Non-kin	<i>h</i>	<i>l</i>
<i>h</i>	<i>h</i>	$A+(1-A)(1-B_N)$	$(1-A)B_N$
<i>h</i>	<i>l</i>	<i>A</i>	$(1-A)$
<i>l</i>	<i>h</i>	$AB_K+(1-A)(1-B_N)$	$A(1-B_K)+(1-A)B_N$
<i>l</i>	<i>l</i>	AB_K	$A(1-B_K)+(1-A)$

Each individual is exposed to a relative (kin) and a nonrelative (non-kin) transmitting a cultural trait relevant to fertility. The entries in the table show how the model assumes that the trait will be transmitted for each possible combination of kin and nonkin. Thus, in the first row of the table, the probability that the adolescent ends up carrying the high-fertility variant is *A* from the unbiased transmission from the kin plus the $(1-A)$ weight of the non-kin times $(1-B_N)$, the probability that the non-kin teaches the high-fertility variant that they themselves carry. An adolescent with two *h* socializers can only acquire the low fertility via the non-kin’s biased teaching, $(1-A)B_N$, and so on for the other three possible combinations of kin and non-kin. Since *p* and $1-p$ give the frequencies of *h* and *l* socializers respectively, Eq. (1) is arrived at by multiplying the frequency of each four combinations of socializers times the probability that pair of socializers results in an *h* adolescent and summing overall four combinations of socializers. We have only two cultural variants, so if we know *p*, we also know $(1-p)$ and need only to keep track of the frequency of *h* or *l*, not both.

The ratio of the fitnesses of the variants (*h:l*) is $(1+s):1$. Let *p* represent the frequency of the *h* variant in the population among socializers; *p'*, the frequency of *h* in adolescents after biased modeling; and *p''*, the frequency of *h* in the socializers of the next generation after both natural selection and biased teaching. The frequency of *l* is $1-p$.

The partial recursion based on Table 3 for the biased teaching step of the life cycle after a little algebra is

$$p' = p + (1-p)B_K(1-A) - pB_N(1-A). \tag{1}$$

The partial recursion for the natural selection step of the life cycle is

$$p'' = \frac{p'(1+s)}{\bar{w}}, \text{ where } \bar{w} = p'(1+s) + (1+p'). \tag{2}$$

The complete recursion, obtained by substituting Eq. (1) into Eq. (2) can be expressed as

$$p'' = \frac{[p + (1-p)B_K(1-A) - pB_N(1-A)](1+s)}{\bar{w}} \tag{3}$$

p' is thus the state of the population after biased socialization, and *p''* is the state of the population after biased transmission and selection. The complete recursion thus models the change in the population over one generation. Assuming that the parameters of the system are fixed, we can now analyze how the population will behave in the long run by conceptually iterating Eq. (3) recursively for many generations. That is, the *p''* of the first generation becomes the *p* of the second generation, and so on for as many generations, as we wish to carry out the calculation.

If we imagine iterating the recursion until the frequency of h no longer changes, we can see where the system will end up after many generations. Analyzing for the equilibrium in this case is comparatively easy. We subtract p from both sides of Eq. (2) to keep the notation compact:

$$p'' - p = \frac{p'(1+s)}{\bar{w}} - p = \frac{p'(1+s) - p\bar{w}}{\bar{w}} \quad (4)$$

At equilibrium, the population does not change, so $p'' - p = 0$. To determine the equilibrium we expand \bar{w} [from Eq. (2)], substitute Eq. (1) into Eq. (4), and solve for p , now symbolized by \hat{p} to denote p at equilibrium. The resulting equation has terms in p^2 . It is solvable exactly using the quadratic formula, but the result is quite complex. The easiest way to get a sense for the behavior of the system is to assume that all the forces are weak. Then, we can ignore all the terms containing s^2 , s times one of the biases or the biases times themselves or each other. All of these parameters are fractions, and small fractions times each other are very small numbers. The weak forces assumption results in a compact and interpretable estimate of \hat{p} , and all the qualitative conclusions we report also hold for the case of strong forces:

$$\hat{p} = \frac{AB_K}{AB_K + B_N(1-A) - s} \quad (5)$$

To test the cogency of the kin influence hypothesis argument, imagine a traditional kinship based society in which A , the weight of kin is large relative to $(1-A)$, the weight non-kin. If the biases are both of roughly equal magnitude, the equilibrium frequency of h , the high-fertility cultural variant will be close to 1. The effect of natural selection on the cultural variants tends to counteract the effect of the non-kin bias in favor of the low-fertility variant, nudging the frequency of h even closer to 1.

When modernization causes social networks to widen and the ratio of kin to non-kin in the social networks declines, the same model predicts an erosion of fitness-enhancing behavior. At the beginning of the process, members of the social network still have traditional pronatal reproductive norms, but when they interact with kin, they express slightly more pronatal versions of the norms than when they interact with non-kin. As Eq. (5) shows, the bias need not be extremely strong in any one generation for the effect to accumulate so that it becomes large over a few generations. The drop in A relative to $(1-A)$ has a direct effect on the frequency of the h variant. As A becomes smaller and smaller, the frequency of the low-fertility norm will now tend toward 1. Natural selection acts keep fertility up, but this effect is not guaranteed to hold as A drops (Boyd & Richerson, 1985, p. 182–186).

We imagine that over a range of human populations, there are suites of cultural variants that prescribe reproductive choices that approach optimality for each local environment. A long history of cooperative reproductive

decision-making in kinship-based groups would have favored individuals who adaptively bias their communication of reproductive strategies to maximize their inclusive fitness. Culture allows human behavior to be flexible, respond rapidly to environmental change, and to be informed by the experiences of many individuals, both kin and non-kin, so that when environments change, reproductive strategies change. A spectrum of societies with considerable variation in reproductive behavior would develop, but in all kinship-based societies, reproductive behavior would be roughly adaptive. This combination of flexibility and fitness tracking is arguably necessary to explain the conditions under which the capacity for culture arose in the human lineage and why culture has led to the extraordinary ecological success of our species (Richerson & Boyd, 2005, Chapter 4).

The results of this model resemble those of many of the models that we and others have developed (Richerson & Boyd, 1984; Boyd & Richerson, 1985) to investigate the effects of innate evolved biases that influence the transmission of cultural information. They produce cultural norms that generally prescribe behavior roughly consistent with maximizing reproductive success and which evolve as ecological conditions change. The model shows that as long as interactions between kin dominate the social processes that generate reproductive norms, fitness-enhancing norms will be fixed in the population. Thus, in the traditional kin-based societies under which the proposed kin teaching biases evolved, the cultural system would remain adaptive, but the equilibrium frequency of fitness-enhancing norms drops in direct proportion to the importance of non-kin interactions in the group processes. The model predicts that in modern kin-sparse social networks, even a small reduction of encouragement to reproduce on the part of nonrelatives compared to relatives will accumulate generation by generation, creating an evolutionary pressure on cultural norms that reduces the extent to which they prescribe behavior consistent with reproductive success.

5. General discussion

Most evolutionary analyses of human reproductive behavior have looked at how genetically evolved biases and preferences may directly affect reproductive behavior by influencing, for example, mate choice, parental investment and gender-specific behavior (e.g. Buss, 1989; Symons, 1979). It is clear, however, that there is a large cultural component to human reproductive behavior and that in many populations this has changed rapidly over the last 200 years with a decline in fertility and gender specialization (e.g. Borgerhoff Mulder, 1998; Buss, 1989; Buss, Shackelford, Kirkpatrick, Larson, 2001; Schmitt, 2005). We have show that this may occur because of an innate bias or preference that has an indirect effect on behavior by influencing the evolution of culture.

Participating in the group processes that create and modify shared behavioral norms is part of the evolved biology of human beings, and this has created a situation in which human behavior is subject to the influence of two inheritance systems, genetic and cultural (Boyd & Richerson, 1985; Cavelli-Sforza & Feldman, 1981). Social interaction can be considered analogous to a mating during which cultural variants may be propagated, and this inheritance system can be subject to analysis by Darwinian methods. The influence of culture on human behavior is therefore not capricious and unpredictable, just very complex.

In this article, we have described a way that cultural evolutionary analysis can be used to explain the series of dramatic changes in human behavior, which begins as social networks deviate from those in which human social behavior evolved and contact between kin ceases to be a very large proportion of human interactions. When individual group members do not share an interest in producing the next generation, the norms they generate do not encourage or facilitate the raising of children. Thus, modernization provides a global scale natural experiment to look at the psychological, social, and cultural consequences of a profound change in the human social environment. The present studies do not reveal the extent to which the kin influence hypothesis can account for the changes in reproductive behavior that begin with modernization, but they reveal it to be a viable explanation that can account for extensive cultural change.

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