1. INTRODUCTION
A number of researchers have argued that humans evolved as cooperative breeders, receiving help with food provisioning and with direct childcare primarily from genetic relatives [1–3]. Grandmothers in particular may play an important role, as they are often post-reproductive when their grandchildren are young, and can hence increase their genetic contribution to future generations by turning their focus to grandparenting [4,5]. Hawkes [6,7] has argued that menopause and a long post-menopausal lifespan may have evolved because grandmothers can contribute substantially to grandchildren’s survival and development, such that natural selection has favoured menopause and grandparental investment over delayed menopause and continued reproduction at older ages. Consistent with this, studies conducted in populations without modern medical care comparing child survival in families with and without a living grandmother frequently show that infant survival is higher in families with a living grandmother (for a review see [5]).

Direct childcare has been quantified in time-allocation studies carried out in foraging and subsistence-level agricultural societies. These show that mothers typically perform around half of the care given to their infants, with the remainder provided by grandmothers, fathers, other relatives and less often by unrelated individuals [8–12]. These time-allocation studies show that grandmothers are a particularly important category of childcare provider, often providing more direct care (such as infant-holding, calming and feeding) than a child’s father. In some groups, grandmothers additionally provide significant food resources to be shared with extended family [4], although this is not true of all hunter–gatherers [13].

Non-maternal care plays a similarly important role in industrialized societies [14], although the types of care arrangement usually differ from those available in non-industrialized, small-scale societies, with day-care facilities, which usually must be paid for, replacing much of the kin-based care that occurred before industrialization. Turke [15] and Bereczki [16] have argued that childcare constraints affect women’s reproductive decisions such that fertility will be lower whenever easily accessible kin-based childcare is scarce. They go on to argue that increased childcare constraints could in part underlie reduced fertility levels, which accompany demographic transition in industrializing societies.

Grandparental assistance with child-rearing could affect both infant survival and a couple’s fertility, such that couples with more help will choose to have more children. A number of demographers have studied fertility as a function of family living arrangements in societies containing a mixture of household types. Typically, nuclear families are compared with extended families, with the latter being assumed to have higher availability of childcare help. A number of these studies show higher fertility for women in extended family living arrangements [17–21]. Others have reported negative findings or no significant fertility differential between nuclear and extended households [22,23]. Such inconsistency between studies may reflect methodological differences [24], although an issue raised by Turke [15] is that

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Grandparental investment and reproductive decisions in the longitudinal 1970 British cohort study

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There has been a recent increase in interest among evolutionary researchers in the hypothesis that humans evolved as cooperative breeders, using extended family support to help decrease offspring mortality and increase the number of children that can be successfully reared. In this study, data drawn from the 1970 longitudinal British cohort study were analysed to determine whether extended family support encourages fertility in contemporary Britain. The results showed that at age 30, reported frequency that participants saw their own parents (but not in-laws) and the closeness of the bond between the participant and their own parents were associated with an increased likelihood of having a child between ages 30 and 34. Financial help and reported grandparental childcare were not significantly positively associated with births from age 30 to 34. Men’s income was positively associated with likelihood of birth, whereas women’s income increased likelihood of birth only for working women with at least one child. While it was predicted that grandparental financial and childcare help would increase the likelihood of reproduction by lowering the cost to the parent of having a child, it appears that the mere physical presence of supportive parents rather than their financial or childcare help encouraged reproduction in the 1970 British birth cohort sample.

Keywords: fertility; grandmother hypothesis; childcare; alloparenting; resources; reproduction

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residence with kin does not directly address whether kin actually perform childcare or provisioning. Some research addressing this issue does suggest that access to childcare increases fertility [16,25]. Of the few studies that have addressed grandparental help and fertility in modern, industrialized nations, Kaptijn et al. [25] found that families receiving regular grandparental childcare help were more likely to have a child in the next 8–10 years, statistically controlling for the distance between parents’ and grandparents’ residences.

Any fertility response to the availability of childcare assistance must be mediated by proximate mechanisms, and there appear to be a number of potential mechanisms that could result in associations between fertility levels and available childcare. Social and kin support affect cortisol levels [26], which in turn can associate with infecundability [27,28]. A second set of potentially relevant proximate mechanisms consists of fertility-related behaviour and motivation, often measured in research simply by asking individuals for information on their desire for children, frequency of sexual intercourse, use of birth control and other interview- or questionnaire-based measures of motivation to reproduce [29–31]. Through these and other potential mechanisms, receiving help with childcare may reduce both the perceived and actual costs of reproduction and motivate the desire for larger family sizes and concomitant behaviour.

The purpose of the present study was to test the hypothesis that grandparental childcare, the closeness of the relationship with grandparents, and financial support are associated with an increased likelihood of birth following the period of childcare help. The data were drawn from the 1970 British cohort study (BCS70), which contains data collected approximately every 4 years on various aspects of family, work and health in 17,000 individuals born in a single week in 1970. The BCS70 data allow analysis of relationships between perceived and self-reported parental support and grandparental care at age 30 and the likelihood of having a child between 30 and 34.

Paternity uncertainty may produce different patterns of involvement of maternal and paternal relatives, resulting in bias towards investment by maternal kin [5]. For this reason, investment from maternal and paternal kin was analysed separately using the BCS70 data.

2. METHODS
(a) Sample and participants
The BCS70 sample consisted of 17,198 births in England, Wales, Scotland and Northern Ireland between 5 and 11 April 1970. Follow-up data were collected for the sample at several points in childhood and adulthood (5, 10, 16, 26, 30, 34 and 38). Here, data collected from the sample by telephone interview when they were 30 and 34 year-old were analysed [32,33]. Owing to loss of data at follow-up and missing data for some variables, sample sizes for full regression models predicting births between 2000 and 2004 were approximately 8900. Ninety-six per cent of the BCS70 sample classified themselves as ethnically White, with the highest proportion of other ethnicities being Indian (0.9%, 99 individuals) and Pakistani (0.6%, 66 individuals).

BCS70 data collection has focused on various aspects of health, education, child care, career progression, housing, opinions and values. Topics included in the follow-up interviews have varied according to the life stage of the participants, as well as the predominant research interests and issues of the particular time and those of researchers involved in the project. For the purposes of studying grandparental investment, the most detailed interview data were collected in 2000. These data allow analysis of continued financial investment by parents in the participants, whether grandparental childcare was performed, data on how close participants felt to their parents and how often cohort members reported seeing their parents and in-laws.

(b) Variables and statistical procedures
(i) Dependent variable
The dependent variable represents whether the cohort member bore or fathered a child in the 4 year period following interview in 2000. Binary logistic regression was used to analyse the data.

(ii) Independent variables
Two measures of financial assistance from cohort members’ parents were analysed: the interview contained questions about types of assistance received from parents since leaving full-time education. A new variable was defined where if no help was received it was coded as 0, if either cash help or help with housing was received it was coded 1 and if both were received it was coded 2. The second variable was defined using reported amounts of money regularly received from parents and other relatives and the time period over which they were given during the year prior to the interview.

Parental assistance with childcare since the end of education (i.e. grandparental care) was included as a binary variable. The interview contained slightly more detailed information on the childcare arrangements in families with two working parents. Current care arrangements for children under 15 were transformed into a binary variable coded 1, where the respondent stated that grandparents provide childcare. Childcare by maternal and paternal grandparents was analysed separately. These variables were analysed in logistic regression models, which excluded participants without one or more children. The BCS70 interview in 2000 included questions about how close participants felt to their mother and father on a 4 point scale from ‘very close’ to ‘have no contact at all’. Closeness to mother and father was added to produce a variable representing reported closeness to parents.

Similarly, the reported frequency of seeing parents was created from separate BCS70 interview questions about the frequency that respondents saw their parents and in-laws.

(iii) Controls
A probable strong predictor of whether the cohort member had a child between the interview in 2000 and the next interview in 2004 is whether they were married or had a partner in 2000. This was included as a binary variable. Socioeconomic status may affect the timing of reproduction in the cohort, and participants’ income in 2000 and the age that they left full-time education were included as control variables. Family income could be more important than the individual cohort member’s income; thus their partner’s reported income in 2000 (if they were living with a spouse or a partner) was combined into a single variable with the respondent’s income. The number of individuals living in the household in 2000 was included in the statistical models to control for effects of the number of existing children on the likelihood of having a child. This variable also
Table 1. Descriptive statistics for independent variables.

<table>
<thead>
<tr>
<th></th>
<th>women</th>
<th>men</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>s.d.</td>
</tr>
<tr>
<td>earned annual income (£)</td>
<td>5507</td>
<td>9176</td>
</tr>
<tr>
<td>age at completion of education</td>
<td>18.1</td>
<td>2.72</td>
</tr>
<tr>
<td>number of people in household (2000)</td>
<td>2.9</td>
<td>1.2</td>
</tr>
<tr>
<td>cash and housing from parents as end of education</td>
<td>1.06</td>
<td>0.8</td>
</tr>
<tr>
<td>amount of cash from parents (2000)</td>
<td>35.9</td>
<td>525.9</td>
</tr>
<tr>
<td>grandparental childcare ever(a)</td>
<td>0.49</td>
<td>0.5</td>
</tr>
<tr>
<td>current childcare by maternal grandparents(b)</td>
<td>0.41</td>
<td>0.49</td>
</tr>
<tr>
<td>current childcare by paternal grandparents(b)</td>
<td>0.17</td>
<td>0.38</td>
</tr>
<tr>
<td>reported closeness to parents</td>
<td>4.52</td>
<td>1.44</td>
</tr>
<tr>
<td>frequency of seeing own parents</td>
<td>4.3</td>
<td>1.88</td>
</tr>
<tr>
<td>frequency of seeing in-laws</td>
<td>2.09</td>
<td>2.24</td>
</tr>
</tbody>
</table>

\(a\)For respondents with at least one child.
\(b\)Number of children cared for by kin in families with a working mother and at least one child.

includes the cohort member’s step-children, adopted children and other individuals in the household in 2000, as having a full house may deter couples from having more children.

3. RESULTS

(a) Descriptive statistics and grandparenting patterns

Descriptive statistics for the independent variables are shown in table 1. Sixty-four per cent of the sample reported that they had received parental assistance in the form of cash, accommodation or both since leaving full-time education. Women reported significantly more help with cash and accommodation (t-test: n = 11 261, t = −1.96, p = 0.05), although the magnitude of this sex difference was very small. At age 30, only 1.3 per cent of the sample received any cash assistance or gifts in the year prior to the interview. Large cash sums were rarely received: only 16 individuals of 12 212 reported receiving cash amounts of £5 000 or more in the year prior to interview at age 30.

While significant financial investment by parents was very infrequent in the BCS70 sample by age 30, grandparental childcare for those with children 14 years old and under was relatively common. A usual childcare arrangement for families with a working mother was maternal grandparents for 30.5 per cent of parents (1088 of 3567 participants with a child of 14 or under). Paternal grandparents were reported as usual childcare providers for 18.4 per cent of parents. This difference was statistically significant: Fisher’s exact test (p < 0.0001), and driven by female cohort members reporting a higher frequency of childcare by their own parents (table 1).

Participants reported seeing their parents on average about once a month or slightly less often (table 1). Under the cooperative breeding hypothesis, it might be expected that those with children would see their parents more than individuals without children in their household, especially given the finding reported above, that grandparents commonly provided childcare. This was confirmed in a linear multiple regression model predicting reported frequency that the cohort member saw their parents: individuals living alone or as a couple reported seeing their parents significantly less than those with one or more children (biological, step- or adopted) in their household (coded as a binary variable), statistically controlling for the sex of the cohort member (β = 0.24, t = 25.45, p < 0.0001, n = 11 175). Although cohort members with children in their household reported seeing their parents more frequently, they did not report having closer relationships with their parents than couples or those living alone. In a sex-controlled multiple regression model predicting reported closeness to parents, for the binary variable representing living with children in the household versus not (β = 0.01, t = 1.34, p < 0.18, n = 11 175). In this regression model, sex was associated with reported closeness to parents, with women reporting closer relationships with their parents (β = 0.09, t = 9.12, p < 0.0001, n = 11 175).

(b) The influence of control variables on likelihood of birth

Perhaps not surprisingly, a highly influential predictor of the likelihood of becoming a parent was not being married or living with a partner (odds ratio = approx. 0.22; table 2). Women were significantly more likely to have a child than men in both time periods, which is consistent with previous research on reproduction using the BCS70 survey [34]. This is likely to be because men tend to have children at later ages. Having more people in the household significantly reduced the likelihood of a birth occurring between 2000 and 2004.

Age at completion of education did not associate significantly with likelihood of birth in the presence of the other control variables in logistic regression models. Combined family income and parental financial assistance to respondents were highly positively skewed and had high kurtosis values. This was improved by log-transformation following adding a constant (1) to handle cases in which the value was zero. Combined family income was positively associated with likelihood of birth: in a model of likelihood of birth between 2000 and 2004 for both sexes including all control variables (β = 0.02, s.e. = 0.009, Wald’s test = 4.58, p = 0.032, Exp(β) = 1.02). Further analysis suggested that the income effect was driven by an association between men’s income and their likelihood of having a child: in logistic regression models, women’s income did not significantly affect either men’s or women’s likelihood of birth, and men’s income was significantly
Table 2. Results of logistic regression models predicting birth of a child between 2000 and 2004. (Each independent variable was entered separately into the regression with the four control variables (listed first), *p < 0.05; **p < 0.01; ***p < 0.001.)

<table>
<thead>
<tr>
<th>variable name</th>
<th>women only (n = 4721) odds ratio</th>
<th>men only (n = 4193) odds ratio</th>
<th>both sexes (n = 8914) odds ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>not married or living as married</td>
<td>0.21***</td>
<td>0.23***</td>
<td>0.22***</td>
</tr>
<tr>
<td>household size</td>
<td>0.73***</td>
<td>0.76***</td>
<td>0.74***</td>
</tr>
<tr>
<td>male partner’s income</td>
<td>1.07**</td>
<td>1.06**</td>
<td>1.06**</td>
</tr>
<tr>
<td>female partner’s income</td>
<td>0.03</td>
<td>0.04</td>
<td>1.02</td>
</tr>
<tr>
<td>reported closeness to own parents</td>
<td>1.06*</td>
<td>1.06*</td>
<td>1.05**</td>
</tr>
<tr>
<td>how often sees own parents?</td>
<td>1.03*</td>
<td>1.06*</td>
<td>1.04**</td>
</tr>
<tr>
<td>how often sees in-laws?</td>
<td>0.01</td>
<td>0.02</td>
<td>0.99</td>
</tr>
<tr>
<td>how often sees own parents + in-laws?</td>
<td>0.02</td>
<td>0.103</td>
<td>1.02</td>
</tr>
<tr>
<td>cash and housing from parents</td>
<td>0.96</td>
<td>0.96</td>
<td>0.96*</td>
</tr>
<tr>
<td>parental financial help in past year</td>
<td>0.97</td>
<td>1.05</td>
<td>1.05</td>
</tr>
</tbody>
</table>

Table 3. Results of logistic regression models predicting birth of a child between 2000 and 2004, carried out to examine current grandparental childcare from paternal and maternal grandparents in families with one or more children (with or without a working child) (*p < 0.05; **p < 0.01; ***p < 0.001).

<table>
<thead>
<tr>
<th>variable name</th>
<th>women only odds ratio</th>
<th>men only odds ratio</th>
<th>both sexes odds ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>not married or living as married</td>
<td>0.10***</td>
<td>0.71</td>
<td>0.15***</td>
</tr>
<tr>
<td>household size</td>
<td>0.28***</td>
<td>0.42***</td>
<td>0.34***</td>
</tr>
<tr>
<td>male partner’s income</td>
<td>1.06</td>
<td>1.06</td>
<td>1.02</td>
</tr>
<tr>
<td>female partner’s income</td>
<td>1.23*</td>
<td>1.2</td>
<td>1.15*</td>
</tr>
<tr>
<td>current maternal grandparental childcare</td>
<td>1.12 (n = 1524)</td>
<td>0.92 (n = 1388)</td>
<td>1.03 (n = 2912)</td>
</tr>
<tr>
<td>current paternal grandparental childcare</td>
<td>1.14 (n = 1524)</td>
<td>1.06 (n = 1388)</td>
<td>1.1 (n = 2912)</td>
</tr>
<tr>
<td>grandparental childcare ever</td>
<td>0.87 (n = 2719)</td>
<td>0.87 (n = 2188)</td>
<td>0.87* (n = 4907)</td>
</tr>
</tbody>
</table>

associated with an increased likelihood of birth to their partner (table 2). On the basis of these initial analyses of the control variables on likelihood of birth, regression models of the grandparenting-related variables included household size, men’s and women’s income, sex of the respondent (in analyses with both sexes included), and whether they were living with a partner or a spouse.

(c) The influence of grandparenting variables on likelihood of birth
Because cooperative breeding may be more likely in maternal lineages owing to paternity uncertainty, and male reproduction may have different influences on it to female reproduction, the sample was split by sex, and investment from maternal and paternal grandparents was analysed separately where possible. Table 2 shows results of logistic regression models of the predictors of giving birth to or fathering a child between the ages of 30 and 34, with table columns showing the sample split by sex, and for both sexes together statistically controlling for sex. Each of the parental relationship variables was entered separately into the logistic regression models with the control variables, as the financial investment variables were significantly correlated with each other, as were each of the variables representing closeness to parents and how often participants reported seeing their parents and in-laws. Of the parental assistance variables, financial support was not associated with births in the predicted direction: receipt of financial support and housing since leaving full-time education was significantly negatively associated with the likelihood of birth with both sexes included in the analysis (table 2).

Reported closeness to own parents was associated with an increased likelihood of female cohort members’ having a birth between the ages of 30 and 34, as well as significantly predicting birth in the logistic regression model for both sexes together. Reported frequency that the cohort members saw their parents was significantly associated with birth for both sexes. The frequency that cohort members reported seeing their in-laws was not significantly associated with likelihood of birth.

Potential associations between whether grandparents had in the past provided childcare for the respondent’s children and likelihood of birth were explored using only respondents with at least one child by 2000. For cohort members with one or more children under age 15 and a working mother in 2000, the BCS70 data additionally included whether grandparents currently provided care. Table 3 displays results of logistic regression models of effects of both measures of grandparental childcare. Only one of these grandparental care variables was significantly associated with likelihood of birth: for both sexes of cohort member analysed together, ever receiving grandparental childcare was associated with a lower probability of birth. Women’s income was significantly positively associated with having a child between 2000 and 2004 for women with one or more children by the age of 30.

4. DISCUSSION AND CONCLUSIONS
Cohort members with children were almost twice as likely to report receiving childcare from mater than from paternal grandparents. This is consistent with the
hypothesis that maternal grandmothers should be most likely to invest because they are the only grandparents with a certain genetic link to their grandchild. However, much of the effect could simply stem from mothers, as the main care providers, feeling that they can more comfortably ask their own parents to provide childcare.

Cohort members with children aged 14 and under were far more likely to report seeing their parents frequently than those without children. This pattern is consistent with cooperative breeding, suggesting that parents become more important to individuals when they have young children in the household, and consequently time spent with parents increases. An alternative interpretation of this finding is that individuals who maintain close ties with their parents are more likely to have children, rather than increasing contact with parents after having children. This interpretation is also consistent with the cooperative breeding hypothesis.

Two measures of the relationship between adult children and their parents: frequency that adults reported seeing their parents, and reported closeness of the relationship were significantly associated with an increased likelihood of having a child within 5 years of reporting the quality of the relationship, although the magnitude of the effects were fairly modest: odds ratios for these variables were 1.05 and 1.04, respectively. However, it should be noted that this effect is for a single 5 year period: the BCS70 data collection did not allow for analysis of other time periods, and it is difficult to know whether parents’ moral support is more or less important as an influence on reproductive decisions at other times in individuals’ reproductive careers. If the effects are similar for reproduction at other ages, then cumulatively a close relationship with parents will have a much more substantial effect on total fertility than what the odds ratios reported here suggest.

The regression analyses revealed no evidence in the BCS70 data to suggest that grandparental childcare and financial assistance promote reproduction. This is surprising because practical assistance in childcare and family finances should theoretically reduce the costs of reproduction such that families have more time and resources to devote to future children [35]. In support of this, a similar longitudinal study of grandparenting in contemporary Holland showed that more frequent grandparental childcare was associated with future births in families with one or more children already [25]. Consistent with patterns of childcare across Europe [36], grandparents in the BCS70 sample were frequently described as regular childcare providers, but in the BCS70 sample this did not in turn appear to affect reproductive decisions. Instead, indicators of the closeness of the relationship between adult children and their parents were associated with reproduction. While there are a number of possible interpretations of these findings, one possibility is that humans respond to levels of extended family supportiveness in making reproductive decisions: actual amounts of financial assistance and direct childcare care. Measures of financial and grandparental childcare help did not associate with probability of birth, but assistance could be more important at other periods of the reproductive career, and assistance to adult children may be quite changeable over time as economic conditions change: for example, an increased cost of living and housing may make assistance from parents and grandparental care more important in reproductive decisions of other birth cohorts. Indicators of the presence of supportive parents, but not in-laws, significantly increased the likelihood of having a child between the ages of 30 and 34. The processes underlying the link between parental/grandparental supportiveness and reproduction cannot be ascertained using the BCS70 survey, and warrant further investigation.

I thank two anonymous reviewers and Bobbi Low for very helpful guidance, and Jacqueline Collier for her insights into using the BCS70 data.

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