Plasticity, Life History and Inclusive Fitness: An Evolutionary Demography Perspective on Individual Variation in Fertility and Fertility Preferences in Contemporary Britain

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Declaration

I certify that the thesis I have presented for examination for the MPhil/PhD degree of the London School of Economics and Political Science is solely my own work other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it).

Abstract

This thesis consists of three papers that explore variation in individual fertility and fertility preference. The setting for all three papers is the contemporary UK, though the conclusions have utility for a general understanding of human fertility. All three papers are motivated by theories arising from evolutionary biology, principally inclusive fitness theory and life history theory.

The first two papers investigate actualised fertility and whether patterns of fertility in contemporary Britain are consistent with inclusive fitness theory. Both papers conduct secondary data analysis of the British Household Panel Study. Inclusive fitness theory predicts that because relatives share genes an individual may obtain fitness benefits by increasing the reproduction of a relative. Results support this hypothesis showing that for contemporary British women kin having more opportunities to influence reproductive decision-making is associated with pro-fitness fertility outcomes. In the first paper I find kin accelerate the transition to first birth, and the second paper shows kin also accelerate the transition to second birth.

The final paper tests a different hypothesis derived from evolutionary theory. Life history theory predicts that reproductive strategy should have 'plasticity' and be liable to alter as perceived environmental risk changes. This paper uses primary data collected from University students using an internet experiment and finds that priming respondents using preceding questions on mortality does alter reported fertility preferences, though the effects depend upon the priming, fertility preference measure and the sex of the respondent. The paper also has methodological relevance as it demonstrates the potential for 'context effects' from preceding questions to influence the reporting of fertility preferences.

All three papers present evidence that the incorporation of theories from evolutionary biology have utility in the understanding of contemporary fertility patterns and processes.

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Tables and Figures

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	Paper one	Paper two	Paper three
Conception	RS	PM	PM
Study design	PM / RS	PM	PM / RS
Acquisition and collection of data	PM	PM	PM
Processing and cleaning data	PM	PM	PM
Analysis	PM	PM	PM
Interpretation of analysis	PM / RS	PM / RS	PM / RS
First draft	PM	PM	PM
Substantial re-drafting and editing	PM / RS	PM	PM / RS
Final approval of version to be published	PM / RS	*PM / RS	*PM / RS

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PM Paul Mathews
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INTRODUCTION

1.1 Fertility context of the study population

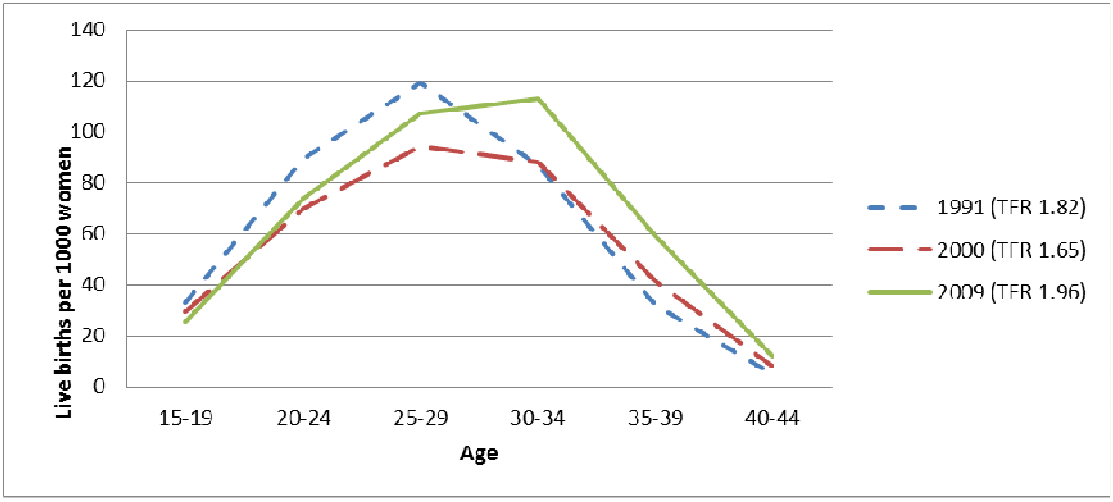
Human fertility is puzzling. Looking at virtually any population's long-run time-series Total Fertility Rate (TFR) and one of the few consistencies will be volatility over time e.g. Livi-Bacci (2001). In this thesis I will be looking at fertility and fertility preferences in Britain since the early 1990s. From the earliest records British fertility has also been consistently volatile. In the 1540s English females had around 4.5 children (Wrigley and Schofield 1981). This decreased to around four children per women in early 17th century and then increased again to around six children per women by the onset of industrialisation in the late 18th century (Wrigley and Schofield 1981). Britain then entered the demographic transition and from the 1870s fertility rates decreased until they fell below replacement level (two children per women) in the 1930s (Coleman and Salt 1992). The post-war baby boom saw fertility rates rise again to peak at three children per women in the early 1960s before falling back to below replacement level by the mid-1970s (Hobcraft 1996).

Over the last two decades fertility rates in the UK and across European societies have continued to change markedly. Throughout the 1990s fertility rates were drifting downwards and in the UK the TFR reached the lowest ever recorded level of 1.63 in 2001. Since then fertility has surprisingly rebounded, with the TFR in the UK 2008 reaching 1.97 before falling back slightly to 1.96 in 2009 (ONS 2010). Goldstein, Sobotka et al. (2009) have argued that this pan-European fluctuation does not yet have a satisfactory explanation. This thesis is broadly looking at fertility in contemporary Britain over the last twenty years and it aims to help further understand fertility patterns and processes through the application of evolutionary theory

As well as changes occurring in overall fertility there have also been considerable changes in the length and composition of the reproductive period and its components: the age of first birth, the birth intervals between each child and the age that reproduction ceases. Over the last twenty years the reproductive period has been shifting backwards with the mean age of first birth increasing from 25.8 years in 1991 to 27.6 years in 2009 and the mean age of any parity birth from 27.8 years to 29.4 years over the same period (ONS 2010; Ni Bhrolchain, Beaujouan et al. 2010). Though at the same time there seems to be shortening

inter-birth intervals for females, certainly for those with a higher education (Rendall and Smallwood 2003). This is likely to be partly a product of postponement as a late age of first birth leaves a relative short 'childbearing window' whereby further births must be compressed into a shorter period before fecundity starts to decline. Less is known about contemporary patterns for the age of last birth, as it can only be calculated at end of a cohort's reproductive life. But it is certainly the case, as can be seen from the age specific fertility rate profile (Figure 1), that there has been an increase in childbearing at later ages. Figure 1 also highlights the variance in reproductive patterns: despite relatively similar TFR's in 1991 and 2009, the age specific pattern has clearly changed.

Figure 1: Female Age-Specific Fertility Rates, England and Wales 1991 - 2009



Source: Office of National Statistics

The rates above are calculated for females, and demographic researchers have traditionally tended to focused on female fertility (Greene and Biddlecom 2000; Preston, Heuveline et al. 2001). Whilst at a population level female fertility equals total fertility, it is wrong to assume that similar trends have occurred for both sexes. Male reproduction has different age (ONS 2010) and socio-economic profiles (Nettle and Pollet 2008). As well as variance by sex empirical studies have also shown substantial differences in British (female) fertility over a whole range of measures, such as education (Rendall and Smallwood 2003), ethnicity (Coleman and Dubuc 2010), country of origin (Tromans, Natamba et al. 2009) partnership arrangements (O'Leary, Natamba et al. 2010), local area deprivation (Nettle 2011). Such is the variation that Sigle-Rushton (2008) argues that one of the most striking

features of British fertility patterns are the 'pronounced' differences that occur beneath the aggregate level trends.

Three fertility variables are analysed in this thesis. Two are actualised fertility measures and are limited to female fertility: i) the transition to first birth and ii) the transition to second birth. The last paper then investigates iii) fertility preferences, defined broadly to include ideals, expectations and value of children measures, and measured for both males and females. This last paper does not use representative data, instead opting for a smaller-scale experimental method. The relationship between fertility preferences and actualised fertility is explored in more detail in the paper but, to put fertility preferences in context, during the period 1991-2007 females' intended family size has consistently exceeded the TFR, though over this period they varied less than the TFR, fluctuating between 2.0 to 2.16 intended children (Ni Bhrolchain, Beaujouan et al. 2010). I am only aware of four papers that actually use representative data for detailed analysis of fertility preferences in the UK (Smallwood and Jefferies 2003; Berrington 2004; Ni Bhrolchain, Beaujouan et al. 2010; Iacovou and Tavares 2011).

1.2 Theoretical context

'An understanding of human evolution, particularly the effects of environmental constraints on age-specific fertility and mortality offers insights not only into our past but into modern problems that are both large scale and urgent' (Clarke and Low 2001, page 633)

This thesis falls within the nascent sub-discipline of demography known as 'evolutionary demography' though it is sometimes labelled under different terms such as 'ecological demography' (Low, Clarke et al. 1992; Low 1993) and sometimes as a subset of 'biodemography' (Carey and Vaupel 2005; Carey 2008) or as the 'biosocial' approach (Casterline 1995; Udry 1996; Foster 2000). Whilst evolutionary demography might be considered a 'new' field within the discipline, the phenomena used to explain actualised and attitudinal fertility levels in this thesis will not appear terribly controversial to many demographers. The two explanatory variables that I analyse are i) *kin influence* on actualised fertility and ii) *perceived mortality risk's* influence on fertility preferences.

The relationship between family and fertility has been part of the social scientific discourse for decades e.g. Davis and Blake (1956) and Young and Wilmott (1957). Similarly demographers can trace the link between mortality and fertility all the way back to Malthus's first essay (1798). However, evolutionary biological theories provide a new underlying theoretical underpinning that looks beyond *how* a given relationship is occurring and focuses on *why* it is occurring. As noted by Clarke and Low (2001) it is often the case that differences between demographers and evolutionary biologists are simply that the former do not link empirical patterns back to 'ultimate explanations'.

Both demographers (Bongaarts 1978) and evolutionary biologists (Tinbergen 1963) divide causal factors of behavioural differences into 'proximate' and 'ultimate' classifications. Though there are some differences between the disciplines in what would be an ultimate or proximate level explanation. For demographers there is often a continuum of causal factors from the highly proximate to more ultimate. As a hypothetical example a standard demographic explanation may say that fertility can decrease at the proximate level because there is increased use of a particular type of contraceptive, at a more intermediate level because of the implementation of a family planning programme, and finally, at the most 'ultimate' level of explanation, because of changes in the population's cultural and socio-economic structure that increase the demand for family planning.

For evolutionary biologists all of the above changes would be considered 'proximate' level mechanisms. Ultimate and proximate causes have much clearer distinctions here due to the pioneering work of Niko Tinbergen (1963). Tinbergen set out that explanations of behaviour should answer four questions: 'Tinbergen's four 'whys'. These answers provide explanations for a particular behaviour at four different levels. These explanations are firstly divided between genotypic and phenotypic levels. The genotype being the genetic composition of the individual; the phenotype being the expression of the particular suit of genes within a given environment. Factors that affect the phenotypic manifestation of the behaviour are considered to be proximate factors. Tinbergen's proximate level mechanisms are then divided between (1) the immediate mechanisms, which result from current environmental stimuli, and (2) the role of ontogeny (the developmental environment) in forming the behaviour. At the ultimate genotype level the behaviour needs to be explained with regards to (3) its ultimate evolutionary function (how the behaviour helps maximise fitness) and (4) the phylogeny of the behaviour (its evolutionary origins, which can be used

to explain observed behaviours which are not adaptive, but may have been in an ancestral environment).

In the terminology of evolutionary biology, 'ultimate' level explanations of behaviour are those which explicitly link to the evolution of the behaviour and the ancestral environment. Research that does not explicitly take into account evolutionary origins is classed as looking at proximate factors. This is simply how evolutionary biologists since Tinbergen have classified their work. In no way is research at the ultimate level inherently better than that conducted looking at the proximate level. For some (human) behavioural questions it is not necessarily useful to consider evolution and it is more appropriate to focus on proximate level factors. For example, to explain 'why is English generally spoken by humans in England?', an ultimate level explanation could require the researcher to link to the evolutionary benefits / costs of complex communication, variance in genes associated with language (i.e. showing there is not an 'English speaking' gene), how infants and children learn from the vocal communications made by other members of their community etc. A proximate answer could ignore these aspects, take as a given that healthy human offspring are born with a capacity to learn language, and instead focus on why the language that children heard during their developmental years in a region of north western Europe was a mixture of Latin and Germanic languages. This is a rather extreme example. However, for the study of variance in human childbearing, I will argue over the next two sections that linking back to evolution (and therefore taking what is called an ultimate perspective by biologists) may add utility over a 'proximate only' approach.

Whilst evolutionary biologists look at ultimate level explanations, the proximate mechanisms must not be ignored. It is important to set out that the notional dichotomous competition in explanation between either genetic 'nature' verses phenotypic environmental 'nurture' is now fundamentally rejected (Ridley 1993). All behaviour is somewhat genetically constrained and similarly the expression of all genes will be influenced to some extent by the environment. Responsiveness to different environments is fundamentally adaptive at the ultimate level. 'Plasticity' to a changing environment will allow an individual member of a species to more appropriately mould its behaviour to the challenges with which it is presented. Phenotypic plasticity is a technical term used by evolutionary biologists to describe and explain both within-individual variation (an organism can change its phenotype over time in response to environmental conditions) and

between-individual variation of organisms of the same species (individuals with the same or similar genotypes can develop different phenotypes in response to different environmental stimuli) (Price, Qvarnström et al. 2003). The concept of plasticity is highly important for the evolutionary theories used in this thesis.

1.2.1 Evolutionary approaches to the study of human behaviour

There are several approaches that seek to incorporate evolutionary biology into the study of human behaviour (Laland and Brown 2002; Brown, Dickins et al. 2011). The fundamental tenant of such theories is that all organisms, including humans, are descended from those within previous generations who successfully passed their genes into future generations. However the approaches differ in their focus on one of Tinbergen's four explanations. Today, there are three main evolutionary approaches to the study of human behaviour: Human Behavioural Ecology, Evolutionary Psychology and Cultural Evolution (Laland and Brown 2002). The Human Behavioural Ecology and Evolutionary Psychology approaches take a traditional perspective by looking at the consequences of Darwinian genetic selection on contemporary human behaviour. Cultural Evolution however uses components of Darwinian 'selection' in cultural rather than genetic terms. A classic example being the description of units of cultural transmission as 'memes', which circulate and diffuse within a culture (Dawkins 1976). Survival of the fittest is thus based on the memes that most successfully survive and replicate. Contemporary Cultural Evolutionary research rarely uses a pure 'memetics' perspective but it does place more emphasis on socially learned behaviour. There are of course several major difference between cultural and genetic evolution. The speed of change in Cultural Evolution can be much faster due to far shorter 'generations' and whilst alleles and genes are relatively clearly defined the boundaries of a 'meme' are far fuzzier. However, compared to the standard social science approaches Cultural Evolution models do place more emphasis on understanding the evolutionary origins, ultimate adaptive functions and potential biases in the social transitions of information (Boyd and Richerson 1985; Blackmore 1999; Mesoudi, Whiten et al. 2004; Richerson and Boyd 2005).

This thesis explores fertility and fertility preferences in contemporary Britain with a theoretical basis broadly rooted in Human Behavioural Ecology, though with some influences from Evolutionary Psychology. There are some important differences between these approaches. Human Behavioural Ecology (Borgerhoff Mulder 1991) has grown out

of the zoological discipline of Ethology / Behavioural Ecology and stresses the role of behavioural flexibility in assisting an organism to adapt to their environmental conditions. Evolutionary Psychology (Tooby and Cosmides 1989; Barkow, Cosmides et al. 1992) arose more out of cognitive psychology and places greater emphasis on the modularity of human cognitive processes. Evolutionary Psychologists tend to look for specific psychological adaptations, whilst Human Behavioural Ecologists look for adaptive behaviour. Both are looking for ultimate level explanations for behaviour though Human Behavioural Ecology analyses how behaviour varies between populations whilst Evolutionary Psychology places more emphasis on universals in human cognition. A key concept in Evolutionary Psychology is thus the Environment of Evolutionary Adaptiveness (the EEA), which is often described as the conditions of the Pleistocene; the historical epoch about 250,000 to 10,000 years ago during which time modern humans, *Homo sapiens*, evolved. Evolutionary Psychology has focused on how complex and novel modern environments differ from the EEA which has led to maladaptive behaviour, as previous adaptations now engender non-fitness maximising behaviour. A classic example being that in ancestral environments it was adaptive to readily consume available sugars and fats as both were scarce yet nutritionally important. This lead to the evolution of cognitive systems with high pleasure rewards from the consumption of these foodstuffs. In our contemporary environment the abundance of both sugars and fats combined with high pleasure rewards for their consumption leads to levels of consumption that cause maladaptive outcomes such as chronic obesity and type II diabetes (Buss 1990).

The differences in theoretical emphasis have led to variance in the types of analysis conducted. Human Behavioural Ecology has typically focused on quantitative ethnographic data from traditional resource-poor societies, whilst Evolutionary Psychology has looked at contemporary high-income populations. Methodologically Human Behavioural Ecology has undertaken more correlational studies of real behavioural outcomes, whilst lab studies are more common, though not universal, as a method in Evolutionary Psychology. Human Behavioural Ecologists and Evolutionary Psychologists are often in different academic departments, with the former regularly being located within (Biological) Anthropology departments. Despite these differences, in the words of Laland and Brown ‘there is little that is genuinely incompatible about their explanations or methodologies’ (2002, page 317) and most of the research in the different subfields of human evolutionary behavioural sciences is best seen as being complementary (Sear,

Lawson et al. 2007). I will return to the more specific predictions and empirical work from these approaches regarding my particular topic of contemporary low fertility in sections 1.2.3 and 1.2.4.

1.2.2 Integrating biological and social approaches to human behaviour

As set out earlier, the variables used in this thesis to explain fertility would not be considered controversial by most demographers. Nevertheless when researchers from a biological background have attempted to incorporate their theories into the study of human behavior there has been resistance to these ideas and approaches from many in the social sciences. Mesoudi, Veldhuis et al. (2010) give three reasons for this: first, particular branches have shifted from being social sciences to humanities and have adopted what Mesoudi, Veldhuis et al. believe to be epistemologically non-scientific perspectives which are incompatible not just with evolutionary biology but with the scientific method in general. This is not necessarily a criticism: just because such work is not scientific does not mean that it is not interesting or useful. A second reason is that hostility to evolutionary theory has been caused by misunderstandings of the theory itself by many social scientists. This has perhaps the greatest potential for correction. As Dunbar (2010) notes, the social sciences separated from the biological sciences early in the 20th century, when large components of contemporary evolutionary theory had yet to be developed. As such, social scientists may hold outdated views of evolutionary theories and associate it with eugenics or Social Darwinism. This is not solely the fault of social scientists. It is also the case that inappropriate or badly constructed applications of evolutionary theory have popularised misconceptions of the use of evolutionary theory in human behavior to social scientists e.g. (Kanazawa (2006) see critique by Dickins, Sear et al. (2007). This thesis attempts to incorporate the rigorous application of contemporary evolutionary theory into the understanding of fertility.

A final reason given by Mesoudi, Veldhuis et al. (2010) for the lack of integration of the social and biological sciences is that social scientists often have been interested in phenomena which appear to be quite removed from evolutionary biology and for which they have considered evolutionary explanations to be insufficient or inadequate. In particular, social scientists regularly look at the emergence and operations of large cooperative human institutions and, more pertinently for this thesis, rapidly changing trends in human behaviors. This is particularly important with regards to human fertility.

The demographic transition has seen the rapid decline of fertility in most societies since the start of the 19th Century, though the speed and onset of the transition has varied tremendously between populations. The decline in fertility, and contemporary low levels of fertility, are in fact considered by Vining (1986) to be 'the central theoretical problem' for the application of evolutionary biological models to study of humans. This is because evolutionary biological models are based on the assumption that the organisms are attempting to maximise their Darwinian fitness. This should mean that those with greater resources are better able to increase their fitness, which should lead to greater numbers of offspring. In humans Vining (1986) argued that the reverse relationship is seen whereby those with the greatest resources actually have the lowest fertility. Understanding contemporary low human fertility is therefore a vitally important task for evolutionary biologists who seek to incorporate humans into their cross-species theories of behaviour.

The speed with which fertility has declined may have also been a contributory factor for demography's relative lack of integration with evolutionary biological principles, as biological explanations were discarded because the speed of the demographic transition is clearly too fast to be the product of genetic evolution of the population. This is an example of social scientists failing to fully appreciate and understand complex biological explanations. As noted by Kaplan (2003), numerous other species have plasticity in their reproductive strategies and are able to rapidly alter their reproductive behavior to fit changes in the local ecology.

Of all the social science disciplines demography is actually one of the best suited for integration with evolutionary biological theories. In fact, in the case of demography this is more a case of 'reintegration' (Sear 2009). Charles Darwin was famously influenced by Thomas Malthus. Early pre-war pioneers of demography such as Alfred Lotka and Raymond Pearl were also highly engaged in biological research (Carey and Vaupel 2005). The disciplines separated in the post-war period for the reasons outlined above. In recent years, however, there appears to be a renaissance of evolution theory within the discipline. For example, Sear (2009) analysed the use of various evolutionary terms in the text of three of the top demographic journals *'Population Studies' 'Demography'* and *'Population and Development Review'* and found that there has been substantial relative growth since the 1970s in the use of *'Evolutionary'* and *'Darwin'* when compared to terms such as *'Anthropology'* and *'Psychology.'*

Demography and evolutionary approaches fit together well. First, demography is traditionally highly quantitative, which fits well with the hypothesis-testing approach of the scientific method. Secondly, both fertility and mortality are directly relevant to fitness and thus predictions drawn from evolutionary theory. Finally, demography has for many decades been uncertain over the role of theory within the discipline, and it has been said more than once that demography 'lacks a theory' (Vance 1952; Keyfitz 1984). This lack of theory is due to the diverse origins of the discipline. One version, the more formal side, is in essence a methodological approach based around the calculation of vital rates from life tables such as the life expectancy and the TFR. Formal demography can be traced back to John Graunt's analysis of mortality in 17th Century of London. This form of demography is essentially an applied branch of statistics and it is rather appropriate that the first life tables were constructed by an astronomer, Edmond Halley (Pavlík 2000). According to Pavlík (2000), asking whether this type of demography needs an overarching theory is inappropriate, and is the equivalent of asking whether statistics, mathematics or logic needs an overarching theory. That is not to say that life tables and their statistical outputs do not contain implicit theoretical relationships. Life tables show the progression of a theoretical population from one age to the next and a standard practice is to produce separate life tables for males and females (Preston, Heuveline et al. 2001). In effect age and sex are the explanatory variables for this form of demography, though it is of course possible to separate life tables by other variables.

The second version of demography is the wider 'population studies' approach to demographic phenomena (McNicoll 1992). Here causation, explanation and understanding the processes of demographic phenomena are of much greater importance (Ni Bhrolchain and Dyson 2007). Overarching theoretical explanations are of much greater utility for this side of demography, and it is interesting that Vance's 1952 call for population studies to incorporate more dynamic processes beyond life tables was echoed by Hobcraft (2006) more than fifty years later.

1.2.3 Demographic and evolutionary theories of fertility variance

There have been numerous attempts made by demographers to explain fertility variation using theoretical models. Most attention has focused on the demographic transition, though many of the theories also apply to fertility variance in general. Standard demographic

fertility theories can be broadly divided into two groups (Newson, Postmes et al. 2005). First, there are the more economically minded theories which focus on fertility decision making by individual actors, who make broadly rational decisions when allocating resources to maximise their utility. Second, there are more sociological models that put emphasis on the role of wider social actors in fertility decision making.

Looking first at the economic rational choice models, the most prominent of these theories would be Becker's micro-economic household models on the utility of children (1960; 1991), but other approaches should also be included, for example intergenerational wealth flows theory (Caldwell 1982), the 'supply and demand' model looking at the desire for children and the capacity for fertility regulation (Easterlin and Crimmins 1985) and McDonald's (2000) gender equity theory on inconsistencies in equity between individual and familial institutions.

The rational choice approach can be summarised in the below quotation from Becker's original article on fertility. *'Children are a source of psychic income or satisfaction, and, in the economist's terminology, children would be considered a consumption good… As consumer durables, children are assumed to provide "utility." The utility from children is compared with that from other goods via a utility function.'* (pages 210-211, 1960). Fertility at the aggregate level is determined by many individual (rational) choices. Fertility decline occurs due to changes in the utility function whereby a smaller number of higher quality children provide greater utility than larger quantities of children. A smaller number of children provide more utility because there are i) greater costs through higher investments in children (such as increasing education) and ii) greater opportunity costs from other forms of consumptions. As the socio-economic context changes so too should fertility.

How do these rational-choice economic theories fit within an evolutionary perspective? First, it is important to stress that such theories are not entirely counter to an evolutionary approach. Fertility as the product of a quantity-quality trade-off fits well with the (human) behavioural ecological school of evolutionary biology (Lam 2003). I explain this in more detail on pages 20 and 21. However, it is necessary from an evolutionary perspective to explain at the ultimate level how and why humans evolved an ability to make 'rational' choices in the allocation of resources to maximise utility. In evolutionary biology the

answer is simple, utility is clearly defined as fitness (genetic representation in future generations), though there are of course many trade-offs and possible errors when an organism is seeking to maximise its fitness (such as the trade-off between survival, current reproduction, future reproduction). Traditionally rational choice economists do not explicitly define utility in fitness terms, and Becker's (1960) approach broadly definitely utility as 'what consumers maximise.' Differences between the economic and evolutionary approaches occur when economists' definition of 'rational utility' does not overlaps with 'fitness', though as I will discuss later it is important to avoid a naïve assumption that genetic fitness is maximised simply through having as many children as possible.

There are two problems with a purely economic rational-choice explanation for fertility. First the entire construction of rational utility is being criticised within the discipline. Prominent economist such Robert H. Frank argue that there is 'often' violation of 'the most fundamental axioms of rational choice' (page 14, 2005) and that the growing influence of 'behavioural' economics within the discipline will shift economics towards a much closer aligned with evolutionary theory. The second problem was that empirical evidence such as the Princeton European Fertility Project (1986) showed there was relatively little correlation between fertility decline across historic European, and changes in the economic determinants that should have altered the costs and benefits of children. Instead it was factors related to the flow of information from an existing low fertility community, such as shared language or religion, that seemed to predict on onset of fertility decline.

From the 1980s a second group of theories on more sociological models put greater emphasis on the role of wider social actors in fertility decision making. For example, Cleland and Wilson (1987) and Van De Kaa (1987) place emphasis on the importance of the diffusion of social norms regarding family, childbearing and contraceptives. There is again another evolutionary discipline, cultural evolution, where there is a relatively good fit between it and the sociological models above. I will again discuss this in more detail later on, though the ultimate level link between the social models and evolutionary adaptiveness is that humans evolved strong social learning mechanisms to help maximise their fitness. Humans will alter their behaviour to fit into the behavioural norms of those around them on the basis that such norms are likely to be beneficial in the given ecology. Sharing information will often be of mutual benefit. The problem with social orientated

models is that whilst they explain the process whereby fertility decline spreads around a given geographic area, they cannot explain the underlying logic of why fertility started to decline in the first place.

Both of the models above do provide some insight into fertility patterns. Nevertheless due to the range and variation in socio-economic conditions at which the demographic transition occurred, Mason (1997) has argued that no single theory is entirely satisfactory from a causal perspective. Szreter (2009) has gone further arguing that with regards to historical fertility decline the notion of a generalisable transition is invalid.

Both Mason and Szreter focused their criticism on fertility decline theories but the problems here are also relevant to explanations for contemporary fertility variance. As noted earlier Western European fertility rates have surprisingly recently increased (Goldstein, Sobotka et al. 2009), and fertility patterns in the UK continue to maintain substantial variance between sub-groups (Sigle-Rushton 2008). Most studies of contemporary fertility do not include a value for the extent of the variance explained in the analysis, but when it is included it is often quite low (less than 10%) (Tavares 2010). The same problem of low explanatory power also afflicts the study of mortality, as seen from standard predictors of longevity in industrialised countries (Christensen and Vaupel 1996).

The weakness (or lack) of satisfying demographic theories has led demographers to look for new theoretical directions in the study of fertility. These have added new variables to the standard set of socio-economic factors for predicting fertility; interesting ‘new’ variables included into fertility analysis (by researchers who are not explicitly evolutionary orientated) include: personality (Tavares 2010) social network density (Kohler, Behrman et al. 2000), intergenerational effects (i.e. sibship size) (Murphy 1999) and happiness (Margolis and Myrskylä 2011). Amongst these new approaches have been calls for the incorporation of a biological and evolutionary perspective and such calls have appeared in many leading demographic journals e.g. (Davis 1986; Udry 1995; Casterline 1995; Udry 1996; Wilson 1999). The incorporation of such models into the analysis of mortality has led to biodemography entering into what Wachter (2008) has called its ‘adolescence’.

There are a number of evolutionary theories for explaining variance in fertility and contemporary low fertility. I will set out some of the main explanations. The first

explanation is that humans do not have a direct desire for children per se but have a predisposition towards finding sexual activity pleasurable, which in the absence of contraceptives leads to childbearing (Pérusse 1993; Potts 1997). But in contemporary environments modern contraceptives and safe abortion mean that optimal levels of sexual activity can occur with very low levels of fertility. This explanation is very much from the Evolutionary Psychology stable which stresses the maladaptive nature of contemporary behavior in novel environments to which our species has not adapted. However, if this was the sole mechanism then given the effectiveness and acceptability of modern contraceptive Morgan and King (2001) can justifiably turn the question on its head and asked 'why have children in the 21st century?' Whilst 'unplanned' births do occur, Morgan and King (2001) argued that most births in high contraceptive prevalence populations like the UK require an active decision to have a child.

The second approach is based around the predisposition towards nurturing (Foster 2000). The maximisation of genetic fitness requires not only reproduction but that an individual's offspring survive until they too can reproduce. Relative to other species, human children and infants are extremely dependent and require substantial investment for prolonged periods of time. To ensure child survival Foster argues human adults would have evolved a predisposition to enjoy the nurturing of children, and that this is a key component in fertility and fertility preferences over and above a simple sex drive. This approach is useful for understanding why the vast majority of individuals have at least one child.

Both the above hypotheses relate to relatively universal predispositions that are seen across human populations, though of course with some individual variation. Both are useful for explaining the current aggregate level of fertility in the UK. Fertility is low, due to contraceptives breaking the link between sex and childbearing, but not at zero due to the continued desire to nurture. They are however less useful for explaining variance in fertility seen between sub-groups of the populations or the changes seen over the last few decades.

A Human Behavioural Ecology argument for the variance in human fertility is that fertility is adaptively responding to current conditions. Like the economic rational choice school decisions are taken (not necessarily consciously) with given resources that maximise an outcome. As stated earlier human behaviour ecologists are more specific in the outcome

maximised, which is fitness, as measured by genetic representation in subsequent generations. However, genetic fitness will not be optimised by blindly maximising the number of offspring. Such a strategy is likely to lead to insufficient investment in each child and thus compromises the long term viability of the strategy. Investment is necessary not only for survival but to ensure that any offspring are able to viably compete to reproduce within their generation. In contemporary circumstances, with low levels of mortality and vast potential for parental investment it may 'pay' in evolutionary terms to have a smaller family (Mace 2000; Kaplan, Lancaster et al. 2002; Lawson and Mace 2010). An important component of this perspective is that fitness is relative to immediate competition, so human fertility responds to small scale ecologies. The nation-state as a unit of analysis is therefore far too large to represent an evolutionarily relevant community. This then allows for the negative association between wealth and fertility at national or regional levels that so exercised Vining (1986). This is because most national populations are highly heterogeneous. Mace (2000) argues that in homogenous modern populations the association remains positive, and this can be seen in small-scale studies (Weeden, Abrams et al. 2006; Gurmu and Mace 2008) or with numerous controls for heterogeneous factors such as education (Fieder, Huber et al. 2005; Hopcroft 2006; Nettle and Pollet 2008).

However, a problem remains. For reduced fertility to have an evolutionary pay-off it needs to increase long run fitness i.e. it must increase the frequency of genes in subsequent generations. It could be adaptive to reduce family size in one generation but this should lead such offspring to be at an advantage in subsequent generations. This does not appear to be the case, at least as measured by the number of surviving grandchildren (Kaplan, Lancaster et al. 1995). A potential solution to this problem is that one component of the quantity- quality trade off could be extra-somatic inherited wealth, so that low fertility maximises both offspring and wealth in the next generation (Mace 1998). But such an approach is not strictly fitness maximisation.

Finally, there is the Cultural Evolution side which stresses the importance of human social learning and this approach links back to the sociological demographic models. Human have substantial capacity to learn from one another and it is argued that the transmission of cultural information may lead to non-adaptive low levels of fertility. In particular, Boyd and Richerson (1985) have argued that the transmission of social norms will be biased so that those with high status will have disproportional cultural influence and individuals will

be more likely to follow the behaviour of high status individuals. In modern societies those achieving high status may do so at the cost of reproductive success, and this low level fertility may then be imitated in the wider population. Whilst acknowledging the importance of social information for our species this approach still has problems. Whilst humans are capable of learning, our species has not evolved what Nettle would call a 'generalized ability to be indoctrinated' (2009, page 233).

In human and non-humans the environment consists of both ecological and social inputs. It is important to stress that the demographic and evolutionary theories outlined above are not mutually exclusive. It is interesting that both the human evolutionary behavioural approaches and the traditional demographic side have produced parallel literatures which seem to split between looking at fertility from a cost/benefit perspective or from a more social/cultural angle. It would seem appropriate to conclude that both hold some utility. Some of the variation in fertility could be due to maladaptive explanations, whilst some of the variance could be down to adaptive functions (Borgerhoff Mulder 1998).

1.2.4 Inclusive fitness theory and life history theory

In this thesis I am using two evolutionary orientated theories. They will be explained in more detail in the relevant papers. Briefly, the predictions tested in the first two articles are drawn from inclusive fitness (kin selection) theory (Hamilton 1964). This theory stresses that in some circumstances the evolutionary fitness of an individual organism can be optimised not through direct reproduction but indirectly by inducing/aiding reproduction in a relative who can pass on the genes that are shared between the two relatives. This means that individuals who are more influenced by their relatives should often have higher fertility than who are more influenced by non-relatives. If such a pattern is seen then the species is classified as ‘cooperative breeding,’ and whether humans are ‘co-operative breeders’ remains an open research question (Mace and Sear 2005). Changing kin influence was one of the first evolutionary demographic theories proposed for explaining fertility variance and decline in humans (Turke 1989). It has recently been extended to hypothesise that the kin orientation of a social network may influence the transmission of norms in the network which in turn influence fertility (Newson, Postmes et al. 2005).

The hypothesis tested in the final paper derives from life history theory (Roff 1992; Stearns 1992). This theory stresses the plasticity of (human) reproduction and how there are

numerous related sets of trade-offs in the allocation of resources, for examples between i) survival, growth and reproduction, ii) future reproduction and current reproduction, iii) mating and parenting effort and iv) offspring quantity and quality. All of these trade-offs are affected by environmental risk and so increasing perceived risk in the environment should alter reproductive strategies. The results seem to support this hypothesis, but I have written up the paper to highlight the effect of small changes in the priming environment from a methodological and survey design perspective, which has particular utility for demography. I believe this is an innovative way of highlighting the uncertainty contained in fertility preferences that has been pointed out by other authors e.g. Ni Bhrolchain, Beaujouan et al. (2010). Such uncertainty is expected from a plasticity-orientated life history view of human reproductive strategy.

1.3. Methods

This thesis follows the hypothesis testing method of scientific enquiry. Hypotheses are drawn from theory. These hypotheses are tested with empirical data. The results are either in the predicted direction, and thus suggest that the theory is true, or they are not in the predicted direction and thus are evidence that the theory is false. Popper's classic thesis of falsification sets out that a scientific theory is never completely proven true, but for a theory to be scientific it must be possible for empirical evidence to prove that it is false (Popper 1959).

However, it is important to avoid 'naïve' falsification. If my results are not in the predicted direction it would be inappropriate to conclude that they falsify general evolutionary theory, the application of evolutionary biology to humans, or inclusive fitness and life history theory. Keetlar and Ellis (2000) argue that the more nuanced version of falsification as set out by Lakatos (1970, 1978) is more apt for evolutionary psychology. This approach stresses two important points. First theories are actually falsified on the weight of evidence (not just a single piece of evidence). Secondly, theories are falsified relative to competing theories and so falsification of a component of a theory does not mean the complete abandonment of theory, as the theories' scope can be modified. A classic example of Popperian falsification is the hypothesis 'all swans are white' which is falsified by the presence of a 'black swan.' Taking a more Lakatosian perspective we would first be sceptical as the purported 'black swan' may have been another black water-bird that has

simply been misclassified as a swan. Secondly, the discovery of black swans in Australia did mean that the theory 'all swans are white' was falsified, however the theory could still be modified to 'all indigenous European swans are white.'

On the first point on the weight of evidence, I stress here and as should be seen throughout the thesis, and the conclusions in this thesis are not 'final' but merely pieces of evidence and that replication is critical. All three papers contain sections detailing the limitations and competing alternative explanations for the observed phenomena. When looking at 'ultimate' theory, it is possible that alternative evolutionary mechanisms could have produced the observed results perhaps as a by-product of the evolution of other traits. The most significant alternative ultimate explanation is through adaptive personality variance, I explain this in more detail on pages (86-89).

The second point on the changing scope of theories is particularly important for Behavioural Ecological work given its concern with cross-species comparison and intra species' plasticity to given environments. In the first two papers I will be testing inclusive fitness theory using data from the BHPS (British Household Panel Survey). The theory that is at risk of being falsified is thus *not* inclusive fitness theory, nor even whether humans are cooperative breeders, but the application of inclusive fitness theory within a specific geographic and temporal setting. It would of course be possible to falsify the statement that humans *per se* are cooperative breeders, but this would require empirical evidence from many different populations in different socio-economic and ecological positions. Such work is beyond the scope of this thesis.

As I will explain in greater detail in the papers, most of the research on human cooperative breeding has occurred in resource-poor societies, and it could be that the theory is limited scope and does not fit the behaviour of resource-rich human populations. The environment of the contemporary UK is very different to the Environments of Evolutionary Adaptiveness, whilst resource-poor environments are probably closer to such environments. So the contemporary UK, as represented in the BHPS, presents a new and interesting dataset to test hypotheses drawn from this theory. Following the logic of falsification the theory that humans in resource-rich societies like the UK demonstrate cooperative breeding behaviour is never 'accepted' but more 'not falsified', however if effects in the predicted direction are found in this novel environment then this should

stimulate more research on this issue of human cooperative breeding in such environments. Regardless of the results seen here, the very limited testing of this theory in such settings means more research with different operationalisations of the dependent and explanatory variables, additional control variables and using different datasets is necessary before opinions are formed on the weight of evidence and scope of this particular theory.

The final paper is motivated by life history theory but due to its methodological write up the focus is more on the hypothesis that preceding questions in general influence the reporting of fertility preference. Clearly again the scope of hypothesis matters, as I sets out in the discussion and general discussion sections of this paper, my experiments represent a test of a limited and specific range of preceding questions and fertility preference measures.

1.3.1 Specific methodologies

Behavioural Ecological work on non-humans has devised numerous methods for testing hypothesis, though two principal techniques are cross-species comparison and intra-species experimental manipulation (Krebs, Davies et al. 1993). Both comparative and experimental approaches are also used in the social sciences (Goldthorpe 2001) but for ethical reasons it is obviously not always possible to directly employ the techniques of non-human Behavioural Ecology on the study of humans. I will discuss the ethical considerations of the research in the next section.

The statistical techniques required for human comparative studies are more complex than for non-humans due to our species' greater ecological and cultural diversity. In the first two papers I use correlational methods on observation data. Specifically I used discrete-time event history analysis to measure the association between indicators of kin influence on the progression to a first birth and then separately to a second birth (Allison 1984; Box-Steffensmeier and Jones 2004). This technique is also widely utilised in Human Behavioural Ecology as the time-varying nature of the technique fits nicely with Behavioural Ecology's focus on the plasticity of (human) behaviour. More details on the techniques are found within the papers themselves. Causality, in as much as it can be inferred, is due to what Goldthorpe (2001) would call the 'robust association' seen between these indicators and the occurrence of a birth. The associations are robust as they are seen after numerous controls have been put in place in a fairly representative sample of the

British population, and so there is relatively strong 'external validity' in the generalisability of the results (Shadish, Cook et al. 2001). Some caution is still necessary as there will always remain the possibility that the association is confounded by an unobserved variable. In this case the unobserved variable that has the greatest potential to confound the observed relationship is personality variance, however as I set out it is not possible to include an appropriate control.

In the final paper I employ experimental methods. Randomised groups are created that are theoretically systematically identical except for one manipulated characteristic; in this case the preceding 'priming' questions that the participants received prior to measurement of their fertility preferences. Statistical analysis is used to examine the differences between the groups, and the observed differences are attributed to the manipulated characteristic. Experimental studies have strong 'internal validity' (Shadish, Cook et al. 2001), though as the participants were recruited from a non-probability purposive sample caution should be exercised in the extent to which the results can been generalised.

Demographers are often interested in aggregate population level phenomena (Ni Bhrolchain and Dyson 2007), whilst evolutionary biologists have generally focused on the individual (Low, Clarke et al. 1992). This is because evolutionary biology has long noted that selection works on the level of the 'selfish' gene rather than at the group or population level (Dawkins 1976). So it is genetic competition that drives evolutionary selection. This can occasionally be seen within individuals, e.g. genetic imprinting (Haig 1993), though generally within a population it is inter-individual competition, or cooperation, that is of interest to evolutionary biologists. Nevertheless there have been substantial movements in demography towards individual level analysis. Individual-level statistical methods are employed here, as has become standard within population studies, which has adopted both theory and techniques from many other disciplines.

1.3.2 Ethics

The first two papers on kin influence on actualised fertility have limited ethical considerations as they used secondary data from the BHPS (British Household Panel Survey). The Institute of Social and Economic Research administers the BHPS and the data are used in accordance with the Ethical Guidelines of the Social Research Association.

For the final paper there were several ethical considerations that needed to be taken into account. In terms of informed consent, necessary in all human research, the allocation webpage made clear the broad nature of the questions being asked, though it did not jeopardise the validity of the study by explicitly stating that it's experimental nature. The final page of the survey did provided participants with de-briefing. Secondly, the mortality primes had the potential to be upsetting for respondents, for example those who had recently suffered a bereavement. So the covering page stated '*for most people, these questions are unlikely to cause emotional distress. However, you are free to decline participation in this study for any reason at all. You can decline participation immediately or at anytime during the questionnaire. If you find thinking of a response to one of these questions upsetting please skip on to the next question, or close the questionnaire.'* In addition 'Cannot say' and/ or 'Prefer not to say' options were included throughout to allow respondents to easily skip questions. In the de-briefing section I included my contact email address where I requested that participants contact me if they had any concerns, queries or wished to be informed about the results. Nearly eighty participants contacted me, none of whom reported any distress in taking part in the survey. Finally, due to the sensitive and personal nature of the information being collected all of the datasets created maintained the anonymity of the respondent and were stored securely. I obtained full ethical approval from the LSE Research Ethics Committee on 17th October 2008 prior to the collection of any data.

1.4 Structure of the thesis

This thesis consists of three papers that are of publishable quality and they have been written in a format appropriate for publication in a peer review journal. For an academic paper to be publishable it must succinctly communicate the necessary information to the reader. Canter and Fairbairn (2006) argue that articles that are too long, poorly structured or lack a narrative are more likely to be rejected in the peer review process, no matter how original the contribution to knowledge To ensure 'publishability' my papers omit considerable analysis that was necessarily undertaken, but whose inclusion would have made the papers far too dense. Much of this work is referenced in passing and is often simply sensitivity analysis, which generally confirms the assumptions in the presented models. I will include each paper as an entity in of itself, but the second paper is followed by a section of supplementary material that will explore in greater detail the additional

analysis conducted for this paper. Nevertheless the three papers differ in length. This reflects their different aims and objectives.

All three papers were written with different audiences and target journals in mind. The thesis is inter-disciplinary covering in detail work from evolutionary biology, demography and survey methodology. Paper one covers the transition to a first birth and has been sent to a demographic / social science journal, *Demographic Research*. Paper two covers the transition to a second birth but is going to be submitted to an evolutionary journal, *Evolution and Human Behavior*. Paper two covers in more detail the substantive theoretical arguments, particularly in the discussion on the causal nature of the reported associations. This information is relevant for both of kin influences papers but as noted earlier substantial theoretical discussion is more common in the evolutionary field than in demography. Indeed, rather than undertaking empirical analysis, whole tranches of evolutionary biology are devoted to the modelling of theoretical populations and traits (e.g. *Journal of Theoretical Biology, Journal of Mathematical Biology*).

The three papers structure of this thesis reflects the broad range of literature and methods that I have sought to engage with over the last four years. All three papers are nevertheless coherently motivated around the central approach of Behavioural Ecology and all three highlight the importance of Behavioural Ecological factors in the reproductive strategies seen in contemporary Britain.

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PAPER ONE

Does the Kin Orientation of a British Female's Social Network influence her Entry into Motherhood?

Abstract

This study investigates whether a female's entry into motherhood is influenced by the kin orientation of her social network. We use data from the British Household Panel Study (BHPS) and define kin orientation as the number of relatives who a female reports within her three closest non-household friends. Discrete-time event history analysis is undertaken to measure the risk of a first birth, controlling for household composition and socio-economic background. We find that having more kin in one's close social network increases the risk of first birth at all ages, suggesting relatives may influence fertility behaviour in this population.

1. Introduction

Interest in the relationship between relatives and reproduction has waxed and waned. In the immediate post war period until the 1970s substantial attention was given to this area, particularly focussed on the assumption that couples living within extended families would have higher fertility than those living in nuclear households (Davis and Blake 1956; Young and Wilmott 1957). The appeal of this topic then seemed to decline, partly due to methodological and conceptual problems (Burch and Gendell 1970). However, two recent developments in demographic research have reinvigorated interest in this relationship. First, seminal work in the 1980s on models of cultural diffusion established the importance of social networks for fertility behaviour (Boyd and Richerson 1985; Cleland and Wilson 1987). Second, increasing interactions between evolutionary biology and demography have directly raised interest in the effects of kin on reproduction. Evolutionary biology's theory of inclusive fitness predicts that genetic relatives have more reproductive interests in common than non-relatives (Hamilton 1964). Evolutionary demographers are therefore specifically interested in kin, since they are the social network members who theoretically should have the most influence on reproductive behaviour.

The body of empirical evidence testing inclusive fitness predictions on human demographic patterns is small, but it is rapidly growing. This research has largely been conducted on high fertility populations. Here, we use a dataset from a low fertility population, the UK, to test whether the risk of a first birth at all ages is influenced by kin orientation. As a secondary aim, we examine the potential pathways through which kin could influence reproductive behaviour, by investigating whether frequency of contact with kin or their geographical proximity matters more.

2. Literature review

2.1. Social networks and fertility

In recent years substantial research has been undertaken to better understand the effects of social network characteristics on various reproductive attitudes and behaviours (Montgomery and Casterline 1993; Kohler 1997; Montgomery and Chung 1999; Kohler, Behrman, and Watkins 2000; Kohler, Behrman, and Watkins 2001; Behrman, Kohler, and Watkins 2002; Madhavan, Adams, and Simon 2003; Bernardi 2003; Rindfuss et al. 2004; Sandberg 2005; Kuziemko 2006; Helleringer and Kohler 2005; Musalia 2005; Avogo and Agadjanian 2008; Mace and Colleran 2009; Keim, Klarner, and Bernardi 2009; Borgerhoff Mulder 2009; Hensvik and Nilsson 2010). Relatively little of this social network orientated research has focused on actualised fertility outcomes, exceptions being Madhavan et al (2003), Kuziemko (2006) and Hensvik and Nilsson (2010). Instead, it has mainly concentrated on the diffusion of contraceptive knowledge and social norms concerning reproduction. Such research has tended to compare the relative effects of information spreading (social learning) and the social acceptability of behaviours (social influence) (see Montgomery and Casterline 1996). This requires measurement and analysis of a social network's density: how closely tied other individuals (alters) are to one another. High density networks will facilitate social influence whilst low density ones are conducive to the spread of information. Less attention has been paid to the composition of the network, so few studies look at whether alters are genetically related to the measured individual (though there are exceptions e.g. Madhavan, Adams, and Simon 2003; Bernardi 2003; Musalia 2005; Kuziemko 2006; Keim, Klarner, and Bernardi 2009; Mace and Colleran 2009; Borgerhoff Mulder 2009).

Such research has also concentrated on high fertility populations where substantial changes in fertility regulation are taking place, as it has been heavily focussed on whether fertility decline spreads through social networks. Whether fertility behaviour in other contexts is also influenced by social networks and kin interactions is rarely tested. We have found only two quantitative studies in low fertility populations that investigate whether fertility behaviours are affected by social networks, and they looked at quite different types of network (co-workers in Sweden (Hensvik and Nilsson 2010) and siblings in the US (Kuziemko 2006)). Qualitative research set within low fertility populations indicates that kin interactions may influence fertility preferences (see Bernardi (2003) for Italy and Keim, Klarner, and Bernardi (2009) for Germany).

2.2. What effect should kin composition of a social network have on fertility, and why?

Natural selection favours genes which act to increase their frequency in subsequent generations. Relatives by definition share one another's genes. Evolutionary theory therefore predicts that relatives will be interested in increasing one another's reproductive success, provided that the costs of increasing that relative's reproductive success do not outweigh the benefits obtained (weighted by the coefficient of relatedness – the probability that any gene will be shared between the two relatives (Hamilton 1964)). This 'inclusive fitness' includes both the successful reproduction of the individual and their relatives in the measurement of total Darwinian fitness. Hamilton's inclusive fitness theory is vital for explaining the reproductive behaviour of many species, such as social insects, and has recently been used as a framework for interpreting variation in human fertility at both the micro- and macro-levels. It has been argued, for example, that the demographic transition from high to low fertility may have been partly caused by a decline in 'kin influence' (Turke 1989; Newson et al. 2005). During modernisation kin networks fragment, which reduces the opportunities for kin to encourage the reproduction of their relatives, and may also increase the costs of reproduction for parents, as kin are less able to help raise children.

Such an approach has also been applied successfully to individual level analysis of fertility variance. Evolutionary anthropologists have demonstrated in a number of high fertility populations an association between the presence of certain kin and fertility (see reviews by Mace and Sear 2005 and Sear and Coall 2011). Such studies tend to use small-scale anthropological datasets, and have often measured kin influence simply as the presence (or

absence) of a particular relative (mother, father, grandmother, etc) in the community. Nevertheless, this literature suggests that incorporating measures of kin influence may be a fruitful line of enquiry when investigating fertility behaviour.

It should be noted, however, that it is not always in a relative's interests to be blindly pro-natal. Simply increasing the total number of children born to an individual is unlikely to increase genetic representation in future generations. Starting too early or having too many closely-spaced children may result in maternal depletion and sub-optimal investment in each child. It is expected that relatives will act to delay childbearing in environments where a delay allows the acquisition of resources that substantially enhance the outcomes of children born later. We recently conducted a systematic review of kin influence on fertility and found precisely this effect in the four relevant UK studies. As in most other developed societies, parental presence in the household decreased the likelihood of teenage pregnancy or early first births (Sear and Mathews 2009: the UK studies were Kiernan 1992; Russell 1994; Kiernan and Hobcraft 1997; Manlove 1997). Context matters: relatives should only encourage childbearing if the conditions are right for any child produced to become a successful adult i.e. able to compete with others in their cohort to obtain resources, mate and support children of their own. Despite this caveat, we predict that kin *on aggregate* should encourage reproduction and thus increase the risk of a first birth during adulthood.

2.3. Proximate mechanisms through which kin may influence fertility

Inclusive fitness theory explains *why* relatives in general have an interest in improving each other's reproductive success, but it does not explain *how* this is done. Research on these proximate mechanisms is less well developed, but two possible pathways of influence have been suggested.

First, relatives can assist reproduction through the provision of resources and practical assistance (Turke 1989). In resource-scarce environments, providing economic resources or assistance could improve the health and fecundity of a relative, and thus may directly affect fertility. While such direct effects on fecundity are unlikely to be seen in resource-rich environments, the provision of economic resources here might also encourage child-bearing by lowering the costs, or perceived costs, of children. The main reproductive resource envisaged by Turke was childrearing assistance. Childcare considerations are very

relevant in contemporary Western societies. Childcare can be extremely costly if purchased directly, or indirectly through reduced (normally female) employment and career opportunities. If 'free' childcare is available from a relative this will lower the barriers to childbearing. Empirical research has shown that in the UK relatives do regularly provide childcare, indeed it has been suggested that such help has increased in recent years due to greater female employment (Gray 2005). Many working mothers also believe childcare provided by their relatives is 'better' than provision by nurseries and child minders (Wheelock and Jones 2002). Hank and Kreyenfeld (2003) found in Germany that having parents in the same town increased the likelihood of having a first birth, a result they attributed to the potential availability of childcare. A similar effect of parental availability was observed in Italy (Del Boca 2002), though the presence of an adult female's mother in the same municipality in Norway reduced the likelihood of a first birth (admittedly without partnership controls Rindfuss et al. 2007). As well as parental influence, Kuziemko (2006) has shown that in the US a sister's childbearing increases the probability of having a child. The effect is stronger if the siblings live in closer geographic proximity, so Kuziemko attributed the observed effect to cost savings in shared childcare.

The second mechanism by which kin could influence fertility is through communicating information to their relatives that encourages reproduction (Newson et al. 2005). We will refer to this as 'kin priming.' Such priming could range from direct attempts at persuasion to more subtle influences on conversational topics and outcomes. These pro-natal messages of kin may over time lead kin-orientated social networks to develop norms that are more pro-natal. There has been little empirical investigation of such kin priming effects. A notable exception used experimental manipulation of role playing scenarios to demonstrate that individuals gave more pro-natal advice to a hypothetical relative than to a hypothetical non-relative, but only in conditions favourable to reproduction (Newson et al. 2007).

Newson et al argued that non-kin do not 'spitefully encourage each other to behave in ways that detract from reproductive success' (page 370). However, as evolution is marked by competitive selection, it is possible that humans have evolved communication mechanisms to discourage the reproduction of their non-kin competitors. Alternatively it may simply be that networks lacking kin also lack pro-natal messages. Regardless, the aggregate pro-natal messages of kin suggested in Newson's theory are only pro-natal *in contrast* to the aggregate messages of non-kin.

Neither party will necessarily be consciously aware of this kin priming influence. Numerous social psychological studies show that individual actors are often not consciously aware of the stimulus for their behaviour or attitudes (Nisbett and Wilson 1977; Zajonc 2000). Qualitative research in low fertility settings (Rotkirch 2007; Bernardi, Mynarska, and Rossier 2010) has also shown that some individuals do suddenly change from explicitly not wanting children to desiring them, and are then unable to articulate the reason for this change.

Our data does not allow us to draw firm conclusions as to whether it is resources or priming from kin which causes any observed effect. Nevertheless in an attempt to explore these potential pathways of influence, we investigated whether the geographic proximity of kin or the frequency of contact with kin affected the risk of first birth. If geographic distance has a greater effect then this might suggest the main pathway was potential childcare, as childcare can only be provided by those who can physically access the child. Kin priming, on the other hand, simply requires communication with kin, so more frequent contact with relatives would increase the capacity for priming.

2.4. Potential confounding factors

Socio-economic status (SES) could confound the relationship between the risk of first birth and kin orientated social networks, if it were correlated with both fertility and association with kin. There is considerable evidence to suggest that SES affects fertility: most research on contemporary British women has shown that higher SES is associated with delayed childbearing, increased childlessness and reduced lifetime fertility (Ekert-Jaffe et al. 2002; Rendall and Smallwood 2003; Berrington 2004; Ratcliffe and Smith 2006; Kneale and Joshi 2008; Nettle and Pollet 2008; Rendall and Smallwood 2003; Portanti and Whitworth 2009; Rendall et al. 2009; Portanti and Whitworth 2009, but also see Kiernan 1989). Patterns of kin association may also differ between social classes, as greater education and employment opportunities increase social and geographic mobility. Higher socio-economic groups (with more education and employment opportunities) may be less kin oriented. Recent empirical research in the UK shows a negative association between SES and contact with kin, though the magnitude of this effect is often quite weak (Owen et al. 2004; Pahl and Pevalin 2005; Nolan and Scott 2006; Grundy and Murphy 2006; Murphy 2008).

Moreover these studies show that across all socio-economic strata, kin regularly form an important part of an individual's social network.

Nonetheless, in order to avoid any potential confounding we controlled for SES in our models. We also attempted to control for several other potentially confounding factors, such as household composition, sibship size, religious and ethnic background, and geographical mobility. Like SES these factors could plausibly be associated with both fertility and social network structure and thus confound any observed relationship. Household composition and sibship size will partly determine the availability of kin for selection into a non-household social network. Household composition will be related to life course position, as noted previously individuals who live with their parents are at a lower risk of early childbearing. Similarly, sibship size and fertility may be related if there is any intergenerational transmission of fertility (Murphy 1999; Murphy and Wang 2001). In the UK, ethnic and religious groups often display quite different fertility and family formation patterns (Berthoud 2000; Coleman and Dubuc 2010) and simultaneously these groups may also have different family and household structures (Connolly and Raha 2006). Residential mobility has been shown to influence fertility (Grundy 1986 ; Kulu and Milewski 2007) and, as noted above, geographic proximity also affects family contact (Grundy and Murphy 2006).

Finally, we included a measure of the frequency of contact with *all* social network members (not just kin) in order to determine whether it was an individual's general level of social attachment, rather than interactions with kin, that might be causing any observed correlation between social network variables and the risk of first birth.

3. Data and Methods

For our analysis we used the ongoing British Household Panel Study[1] (BHPS). The panel started with 5,500 households in 1991 and had expanded to around 10,000 by 2007. Information is collected in annual waves on each individual in the household. Our analysis

[1] Full question wording, methodology and other documentation available at http://www.iser.essex.ac.uk/survey/bhps We were unable to find an satisfactory weighting so after consultation with staff at the BHPS we have used unweighted data with controls for sample extensions. However as we were unable to fully control for other sampling biases in our panel, such as attrition, our results should not be interpreted as being fully nationally representative.

is restricted to childless females who are at risk of having a first birth, defined as those who are aged 16 to 40 at the time of the interview. We used discrete-time event history analysis to analyse the risk of first birth, which allows us to include censored cases and time-varying covariates (Allison 1984; Box-Steffensmeier and Jones 2004). Strictly speaking we are analysing the timing of the first birth. However, as 'perpetual postponement' is considered a key factor for the high levels of female childlessness in contemporary Europe (Berrington 2004), if relatives influence the timing of first birth, they will also affect the chances of perpetual postponement and thus childlessness.

We confirmed the key assumptions of this method; that the likelihood of the event is equal throughout the duration of each spell, and that the effects of the explanatory variables are equal across all spells, i.e. proportional hazards. Each spell in this case consists of a two year period, since our explanatory variable of interest – social network information – was only collected in alternate years, starting in 1992. We only used the first six occasions when this social network information was collected (we will refer to these collections as 'waves') to allow sufficient time after the interview for the birth to occur. The 'event' of interest was defined as a first birth to the respondent between 9 and 27 months after the interview at that wave. We lagged the event in this way to exclude the possibility that women were pregnant when they were interviewed. We also ran the same models with a slightly different window of 6-24 months for the 1st birth, but this had little impact on the results (not shown[2]). Because social networks are labile over time, we did not want to extrapolate social network information before or after data collection, so females are only considered at risk of a first birth during the measurement period (1992-2003), and only first births which occurred during the measurement period or up to 27 months after the last wave were included. The birth history information was obtained from the consolidated family history file as produced by Chiara Daniela Pronzato (2007). The age of the respondent at the time of the interview was included as a quadratic function. Each model included categorical variables for the wave of data collection, though these were consistently non-significant and are not reported.

[2] All results not presented are available on request from the authors.

3.1. Kin orientation and social networks

We were interested in determining whether females with closer kin ties were at greater risk of first births than those with looser kin ties. We considered individuals with greater kin orientation to be those with a higher proportion of kin in their close social network. This definition of kin orientation is based on the ties between relatives, and should not be confused with the respondents' beliefs in 'family values' and social conservatism. The BHPS collects data on a respondent's close social network, consisting of the three individuals they would choose as their *'closest friends.'* The BHPS includes the caveat that these friends *'should not include people who live with you but they can include relatives.'* We will refer to the three closest individuals as the respondent's 'friendship group.' Respondents were asked whether each member of their friendship group was a relative, and our key measure of kin orientation was the number of relatives in the friendship group. Respondents only rarely answered that all three members were relatives, so the variable was capped at two and treated as a linear scale with units 0, 1 and 2. It should be noted that this description of relatives is subjective not genetic, so non-genetic relatives such as step-siblings or step-parents could also be included. Descriptive statistics for all variables included in the analysis are presented in Tables 1 and 2 (all tables for this paper are located on pages 60 and 64).

Theoretically kin orientation variables should be obtained from a continuously recorded measure of all contacts over the entirety of an individual's social network, combined with additional measures of the influence and strength of the contact and precise measures of genetic relatedness. However, such data are not readily available, certainly not at the nationally representative level. The friendship group used in this study constitutes a social network operationalised at a very close ego-centric level. Defined as just the three closest non-household individuals it is not directly comparable to other conceptualisations of close social networks such as, the 'support clique' (Dunbar and Spoors 1995) or the 'personal community' (Pahl 2005). It would not necessarily be appropriate to assume that the kin orientation of this stratum of the network would be reflected outwards, though Dunbar and Spoors (1995) have argued that this is likely to be the case.

We assessed the frequency of interaction with friendship group members using answers to the question '*How often do you see or get in touch with your friend either by visiting, writing or by telephone?'* For each individual we calculated the number of friendship

group members who were contacted *'most days'* (set as a scale from zero to three) as a general measure of social attachment. A separate variable was constructed for the number of relatives who were contacted 'most days', again capped at two, and used as a explanatory variable in some models whilst the general measure of social attachment (number of friends contacted most days) was included in others (see Results) as a control variable to assess the possibility that it may be the sociability of women, rather than their kin orientation, which influences the risk of birth.

The models were also run using dichotomised versions of the explanatory variables i.e. whether the respondent had *any* relatives in the friendship group. We also checked the 'frequency of contact' variables set at different thresholds. These operationalisations provided similar results to the scale versions (results not shown).

To determine whether geographic proximity of relatives was important, we used answers to the question '*About how many miles away does your friend live?'* It will be harder for a relative to regularly provide practical support, such as childcare, when they live over 50 miles away (the furthest answer option). To assess the combined effects of frequency of contact and geographical proximity we constructed three dummy variables for whether the friendship group contained i) a relative living over 50 miles away, ii) a relative living closer than 50 miles but not contacted 'most days' and iii) a relative living close by and contacted 'most days' (respondents seldom reported being in frequent contact with a relative who lived over 50 miles away).

Finally, we analysed the effect of having a specific relative (i.e. a mother, sister etc) within the friendship group. We did this by running separate models including as the sole explanatory variable whether or not the specific relative had been named within the respondent's friendship group. All specific relatives had a non-significant effect (not shown). Unfortunately this and the geographic proximity question were not asked in wave F of the BHPS (1996) which substantially reduced our sample size for these models.

3.2. Control variables

Table 2 also includes descriptive statistics for our control variables. We controlled for the composition of the respondent's household at the time she reported her friendship group by including variables which specified whether a particular relative (i.e. partner, father,

mother, one or more sisters, one or more brothers, one or more other relatives, one or more other non-relatives) also lived in their household. We also checked several alternative constructions of these variables (such as splitting siblings into younger and older categories), which did not change the results and so are not reported. The total number of individuals in the household was included as a scale variable capped at six.

We attempted to control for the number of non-household relatives. Unfortunately information on the family outside the household was only directly collected at the very end of our study period and there was a substantial amount of missing data. So it was not possible to control for parental mortality, for example. We did include a variable for the number of siblings outside the household but a large number of spells (16%) were also missing a measure of sibship size.

We controlled for SES by including variables for the occupation of the respondent's mother and father when the respondent was 14 years old. We used the Cambridge Scale (CAMSIS[3]) for measurement of parental occupation. The Cambridge Scale is a continuous ranking of occupation groups and is considered a more modern and refined indicator of SES than the UK's Registrar-General classifications (Prandy 1999). Parental occupation is likely to give a more accurate impression of SES than the individual's own occupation or income, given that some of our sample were still in education. Parental occupation also avoids the risk of endogeneity between individual SES and fertility: for example, women planning to have children in the near future may lower their investment in education or career progression. We did nevertheless check individual level time-varying SES covariates for education, income and occupation and these control variables generated similar results to those produced using parental SES controls (results not shown). It should be noted that parental occupation was unavailable for a substantial number of respondents.

The BHPS is relatively ethnically homogenous, so we controlled for ethnicity using a simple dichotomous variable that indicated non-white ethnicity. Religiosity was defined as whether the respondent had ever reported being a member of a religious organisation. Internal migration was operationalised as whether a respondent had moved from a different

[3] For details of its construction see http://www.camsis.stir.ac.uk/review.html

region (broadly similar to the Government Office Regions[4]) in the wave prior to the measurement of the friendship group.

3.3 Other considerations

Three different methods were used to control for missing data. First, where there was substantial missing data, separate categorical dummy variables were included for missing values (see Table 4). Where there was insufficient missing data for this to be possible, the missing value was imputed as the reference category. These are the results we present here. Complete case analysis and imputation by chained equations (Schafer 1995) were also conducted. We also checked for attrition leading to non-reported births by running the models again removing all spells where the respondent's last interview (and therefore opportunity to report a birth) was within 27 months of the measurement of the friendship group. All of these methods produced similar results to those presented and are not shown.

Interactions were run between all control and friendship group variables. These interactions proved to be non-significant or have extremely large and non-credible coefficients (due to small cell sizes) so were not included in the final models. We confirmed the assumption of proportional hazards by considering interactions between all explanatory and control variables and age, and by analysing separately those older and younger than 26 years. There was no evidence that the effects of kin orientation varied by age.

All analysis was conducted using STATA 10.

4. Results

The final dataset consisted of 1,590 female respondents who contributed a total of 4,182 spells. There were 307 (7.3%) occasions where the spell was followed by a first birth. Table 3 shows the bivariate association between number of relatives in the friendship group and first birth, which suggests that females with more kin in their friendship group were more likely to have a first birth during the observation period than those with fewer

[4] See http://www.statistics.gov.uk/geography/gor.asp for details of UK statistical regions.

close relatives (chi-square value = 61.7, $p<0.001$). Table 4 shows the multivariate models. We present nine models to show the effects of our main explanatory variables with and without the addition of various controls.

The regression parameters are presented in their exponentiated form. They represent the change in the risk of the a first birth at any age relative to the variable's reference category; categories where the exponentiated value is greater than one increase the risk of a first birth whilst values less than one indicate that compared to the reference category there is a decreased risk of first birth. Model 1 includes just the number of relatives in the friendship group, age, age squared and the wave of data collection. This model shows that those females who have more relatives in their friendship group have a higher risk of having a first birth at all ages. This effect is statistically significant at the 1% level. Unsurprisingly, the age terms indicate that the risk of first birth increases and then decreases with age.

Model 2 includes the number of friendship group members contacted 'most days', rather than any measure of kin orientation, to determine whether a general measure of social attachment might be influencing fertility. Unlike the composition of the friendship group this measure of general social attachment has a very modest and non-significant influence on the risk of first birth. Model 3 includes both of the above variables as well as controls for household composition and social cleavages. The influence of the kin orientation of the friendship group decreases in magnitude, though the effect remains significant at the 5% level. The frequency of contact with the friendship group variable remains non-significant.

Model 4 shows that when our main explanatory variable is limited to the number of frequently contacted relatives in the friendship group, then kin orientation is still significantly and positively related to the risk of first birth. Model 5 shows the same effect controlling for household composition, ethnicity, religion and migration.

Of the control variables included in Models 3 and 5, unsurprisingly, living with a partner considerably increases the risk of a first birth. The effect of a mother in the household has a marginally significant association with an increased risk of first birth in some models, though this variable drops out of significance when sibship size is controlled for. This variable should also be interpreted with caution since relatively few women have a birth while still living with their mother, and it may reflect uncaptured aspects of SES. Living

with ‘other relatives’ increases the risk of a first birth. This category is very heterogeneous consisting of grandparents, uncles, aunts, half siblings etc, and there were insufficient occasions to allow meaningful analysis of these relatives separately.

Models 6 and 7 include the parental socio-economic controls in models where the explanatory variable of interest is the number of relatives in the friendship group and the number of frequently contacted relatives in the friendship group. Including these controls for SES had little impact on the kin orientation variables, which remained significant at the 5% level. Increasing paternal occupational status significantly decreases the risk of first birth whilst maternal occupational status does not have a significant effect. Rather surprisingly, if paternal occupation is missing there is a significantly lower risk of a first birth. It is difficult to interpret this effect and we suspect that it may simply result from associations between missingness, sample attrition and the non-recording of births.

Finally, our results do not appear to be confounded with sibship size: in Models 8 and 9 sibship size is included in the models as a linear variable capped at 6. The effects of our explanatory variables remain similar. The main effect of sibship size is not associated with risk of birth but a dummy variable indicating missing sibship size was significantly associated with a lower risk of birth. We believe this may also be related to sample attrition.

Our secondary aim was to consider whether relatives’ geographic proximity or frequency of contact had a greater effect on the risk of first birth. Model 10 shows the effect of having relatives in the friendship group at various combinations of geographic distance and contact frequency, with all the control variables used in Model 9 included. The results show that it is only when the respondent has a relative in the friendship group who lives within 50 miles *and* this relative is seen frequently that their effect on the risk of first birth is statistically significant. It should be noted that this model does not include data from wave F (1996) and so has a substantially smaller number of spells (n=3,462). We also ran all our preceding models with this subsample and confirmed that there were not systematic differences between it and our main sample.

5. Discussion

Prominent sociologists have argued that the importance of relatives in Western societies is declining (Popenoe 1988; Giddens 1991), a view that can be traced back to Durkheim (Giddens 1972). Instead individuals are apparently increasingly forming 'families of choice,' whereby non-kin fill the roles traditionally occupied by relatives (Weeks, Heaphy, and Donovan 2001; Roseneil and Budgeon 2004). Our results would appear to contradict the view that it does not matter whether an individual interacts with relatives or with non-kin, at least where childbearing is concerned. The more relatives that a female reports within her friendship group the greater the risk that she will have a first birth. Similar results are seen if the explanatory variable is the number of relatives in the friendship group who are frequently contacted, whereas there does not appear to be any association between the risk of first birth and the overall level of social attachment, measured by the frequency of contact a female has with her friends in general.

Our initial models show a strong relationship between first birth risk and social network composition whilst only controlling for age. Whilst the effect size decreases in subsequent models, largely due to the inclusion of household composition variables, the association between kin orientation and fertility remains statistically significant even after controlling for numerous factors. It is noteworthy that with social network composition variables included in the model, factors such as ethnicity and religiosity are not significant predictors of first birth.

Our research has value for demographers interested in social network influences on fertility. Whilst we were not able to look in detail at the fertility of friendship group members, necessary if we were to examine whether the observed effect was due to respondents conforming to childbearing patterns within their networks (i.e. the degree of social influence), we believe it highlights the importance of explicitly considering the relatedness of a social network. Friends and family have different effects.

Our data also does not allow us to come to any firm conclusions about the proximate mechanisms through which kin influence fertility, but we have attempted to investigate this by constructing a set of variables which combine geographic proximity and frequency of contact with kin. By comparing between a frequently and infrequently contacted relative

who lives within 50 miles of the respondent, we find that it is only the frequently contacted relative who significantly increases the risk of first birth. This implies that communication between kin is necessary for kin to influence fertility, perhaps suggesting a greater role for kin priming rather than the effect simply being due to the prospect of receiving childcare or other resources from a relative (note that even relatives who were contacted 'infrequently' were still considered to be within a female's three closest friends).

However, attempting to distinguish between resources and information provided by kin prior to the first birth may create a slightly artificial dichotomy. Frequently contacted relatives could be seen as more likely to provide practical support such as childcare. Other kin assistance, such as post-natal emotional support, advice or financial help does not require geographic proximity. It is also quite possible, indeed probable, that the resources provided by kin could be an important factor in the progression to later births, when childcare has become a practical reality. Finally, as 'cooperative breeding' was probably an essential feature of the human evolutionary trajectory (Hrdy 2009), communications with kin could have a deeper psychological impact on a female's assessment of her reproductive resources, over and above any conscious calculation of childcare costs. Having children is a life changing, and potentially risky, decision. Some women may require assurances from others before starting childbearing. In addition to her partner, a woman's relatives are likely to form a critical component in her resource network. This may well make their assurances particularly influential.

We were surprised that no significant effects were found for any of the specific relatives contained in the friendship group, given that previous research by evolutionary anthropologists has had success in identifying the influence of specific relatives (see reviews by Mace and Sear (2005) and Sear and Coall (2011)). Our study differs from this previous work, however, in that we tested for the influence of specific relatives who resided outside the household, thereby excluding the influence of those living within the household. It is still possible that differences in life course position and relatedness mean relatives will differ in their influence, and that their failure to reach statistical significance could be due to an insufficient number of observations for each type of relative.

Our study has other limitations. It was not possible to properly control for the size of the pool of relatives outside the household who were available for selection into the friendship

group, though we attempted to partly do so by controlling for sibship size. And whilst we attempted to control for missingness as fully as possible it remains a concern that the control variables for missing sibship size and paternal occupation were significantly associated with a reduced risk of a recorded first birth. The measurement of 'relatives' was also limited as it may have included social relatives such as step-siblings.

Finally, our association between social network composition and fertility remains robust to the inclusion of numerous variables that seek to control for SES and the other social cleavages, but it is possible there are unobserved confounding variables which influence both fertility and social network construction. In particular there may be unobserved personality factors that induce some females to maintain close contact with their families and have stronger desires for children. I will discuss the role of personality in the greater detail in Paper Two. There also remains a possibility of reverse causation if women become closer to their relatives, especially perhaps to their parents, in preparation for the onset of childbearing. Whilst this is possible, the substantial time lag (up to 18 months between measurement of the family group and conception) would indicate a level of forward planning not regularly seen in the qualitative descriptions of fertility decision making (Rotkirch 2007; Bernardi, Mynarska, and Rossier 2010). Moreover both personality differences and reverse causation would remain consistent with the central theme of this paper: family is important for childbearing and childraising.

Kinship is one of the fundamental cornerstones of human society, and has been throughout our evolutionary history. Even in a complex contemporary society its influence is felt on one of the most important questions an individual faces in their adults lives: whether and when to become a parent.

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Table 1: Percentage of spells where the respondent has the following number of individuals in her friendship group (% by row)

Number of	*0*	*1*	*2 or 3*
... relatives in friendship group	2535 (60.6%)	1241 (29.7%)	406 (9.7%)
... friendship group members contacted 'most days'	1067 (25.5%)	1394 (33.3%)	1721 (41.2%)
... relatives in friendship group contacted 'most days'	3447 (82.4%)	603 (14.4%)	132 (3.2%)

Table 2: Descriptive statistics of other explanatory and control variables

Descriptive statistics of other categorical variables	*Number of spells*	*Percentage of spells*	*Percentage of which are followed by a 1st birth*
Distance and frequency of contact to relatives in the friendship group			
No relatives in the friendship group	1647	39.4	5.0
Respondent had a relative in the friendship group who lived over 50 miles away[5]	373	10.9	9.1
Respondent had a relative in the friendship group who lived under 50 miles away and was contacted 'most days'[5]	526	15.3	11.4
Respondent had a relative within 50 miles and this relative was contacted 'most days'[5]	497	14.5	14.5
Household contains			
Only respondent	567	13.56	2.8
Partner	1403	33.6	16.2
Mum	1770	42.3	3.5
Dad	1424	34.1	3.0
One or more sisters	678	16.2	2.4
One or more brothers	821	19.6	3.3
One or more non-relatives	537	12.8	2.6
One or more other relatives	119	2.9	7.6
Number of siblings (used a continuous variable in model)			
0	315	7.5	7.3
1	1509	36.1	8.0
2	954	22.8	9.1
3	366	8.8	8.7
4	177	4.2	7.3
5	80	1.9	7.5
6 or more	74	1.8	12.1
Missing	707	16.9	2.4
Respondents who have ever attended religious organisations	578	13.8	8.5
Non-white ethnicity	137	3.3	5.8
Internal migration from last wave	245	5.9	5.7
Internal migration missing	204	4.9	4.4
Respondent lives in England	3765	90.0	7.2
Respondents lives in Scotland	260	6.2	9.6
Respondents lives in Wales	157	3.8	6.4
Cambridge Occupation Score of respondent's father: unavailable	1622	38.8	5.2
Cambridge Occupation Score of respondent's mother: unavailable	2185	52.3	6.9
Descriptive statistics of continuous variables	*Mean*	*Standard Deviation*	
Age at time of interview (years)	24.6	6.2	
Cambridge Occupation Score of respondent's father[6]	21.4	22.9	
Cambridge Occupation Score of respondent's mother	17.9	22.4	
Number of individuals in the household (capped at 6)	2.8	1.3	

[5] Not measured in Wave F

[6] The higher the Cambridge Occupation Score the higher the 'status' of the occupation

Table 3: Crosstab between number of family in friendship group and whether the event ends in a birth (% by column)

	Spells with no birth 9-27 months afterwards	*Spell with a first birth 9-27 months afterwards*
Reporting no relatives in friendship group	2408 (62.1%)	127 (41.4%)
Reporting one relative in friendship group	1120 (28.9%)	121 (39.4%)
Reporting two or three relatives in friendship group	347 (9.0%)	59 (19.2%)

Table 4: Relative risk of a first birth from multivariate discrete-time event history analysis models with the number of family in the friendship group as the main explanatory variable

	Model 1	*Model 2*	*Model 3*	*Model 6*	*Model 8*
Number of relatives in friendship group	1.58***		1.21**	1.21**	1.21**
Number of friendship group contacted 'most days'		0.99	1.06	1.04	1.03
Household contains (ref: Lives alone)					
Partner			6.27***	6.07***	5.88***
Mum			1.73*	1.78*	1.69
Dad			0.66	0.61	0.64
One or more sisters			0.64	0.64	0.61
One or more brothers			1.02	1.01	0.98
One or more non-relatives			0.56	0.56	0.61
One or more other relatives			2.99***	3.08***	2.95**
Household size (capped at 6)			1.02	1.00	0.99
Ever a member of a religious organisation (ref: Never a member)			1.10	1.18	1.13
Non-white ethnicity (ref: white ethnicity)			0.96	0.96	0.94
Internal migration from last wave (ref: No migration)			0.88	0.88	0.83
Internal migration missing			0.53*	0.58	0.78
Respondents lives in Scotland (ref: England)			1.29	1.29	1.37
Respondents lives in Wales (ref: England)			0.81	0.83	0.85
Cambridge Occupation Score of respondent's father				0.99**	0.99*
Cambridge Occupation Score of respondent's mother				1.00	1.00
Cambridge Occupation Score of respondent's father: missing				0.54***	0.62**
Cambridge Occupation Score of respondent's mother: missing				1.26	1.23
Number of siblings (capped at 6)					1.07
Number of siblings: missing					0.31***
Age	1.86***	2.01***	1.33***	1.29**	1.33**
Age^2	0.99***	0.99***	0.99***	0.99***	0.99**

Controlling for wave of collection (non-significant in all models)***p <0.01; **p <0.05; *p <0.1

Table 5: Relative risk of first birth from multivariate discrete-time event history analysis models with the frequency of contact with relatives included as the explanatory variable

	Model 4	*Model 5*	*Model 7*	*Model 9*	*Model 10*[7]
Number of relatives contacted 'most days' in friendship group	1.62***	1.30**	1.28**	1.26**	
A relative in the friendship group who lived over 50 miles away					1.24
A relative in the friendship group within 50 miles					
Not contacted 'most days'					1.14
Contacted 'most days'					1.48**
Household contains (ref: Lives alone)					
Partner		6.30***	6.14***	6.00***	6.81***
Mum		1.69	1.75*	1.67	1.74
Dad		0.67	0.61	0.66	0.84
One or more sisters		0.64	0.64	0.62	0.72
One or more brothers		1.02	1.01	0.99	0.97
One or more non-relatives		0.57	0.56	0.60	0.69
One or more other relatives		3.03***	3.11***	2.99***	3.39***
Household size (capped at 6)		1.02	1.00	0.99	0.84
Ever a member of a religious organisation (ref: Never a member)		1.10	1.17	1.13	1.13
Non-white ethnicity (ref: white ethnicity)		0.95	0.94	0.93	0.69
Internal migration from last wave (ref: No migration)		0.87	0.87	0.83	0.72
Internal migration missing		0.52*	0.57	0.78	0.70
Respondents lives in Scotland (ref: England)		1.25	1.26	1.35	1.74**
Respondents lives in Wales (ref: England)		0.80	0.81	0.84	0.92
Cambridge Occupation Score of respondent's father			0.99**	0.99*	0.99
Cambridge Occupation Score of respondent's mother			1.00	1.00	1.00
Cambridge Occupation Score of respondent's father: missing			0.55***	0.62**	0.69
Cambridge Occupation Score of respondent's mother: missing			1.27	1.24	1.18
Number of siblings (capped at 6)				1.07	1.10*
Number of siblings: missing				0.32***	0.32***
Age	1.91***	1.32**	1.28**	1.32**	1.22
Age^2	0.99***	0.99***	0.99**	0.99***	0.99**

Controlling for wave of collection (non-significant in all models)***p <0.01; **p <0.05; *p <0.1

[7] Wave F excluded from analysis in this model

Supplementary Material for Paper One 'Does the Kin Orientation of a British Female's Social Network influence her Entry into Motherhood?'

1) Background information on BHPS sample

a. Inclusion of temporary and booster sample members

There were only a limited number of spells contributed by booster sample members, i.e. those respondents who had been included in the additional samples for devolution monitoring and the European Community Household Panel (ECHP). I therefore kept all the available information within the dataset, and included control variables for the devolved countries. I included information from temporary sample members when it was available.

Table 1: Breakdown of sample members by wave

	% of spells from each sample contributed in each wave						Total	
	1	2	3	4	5	6	Number of spells	Total %
Original sample	100	100	100	98.67	93.38	94.55	4,096	97.94
ECHP - scpr	0	0	0	1.03	1.05	0	14	0.33
ECHP - ons	0	0	0	0.3	0.9	0	8	0.19
Wales new sample	0	0	0	0	1.65	2.98	29	0.69
Scotland new sample	0	0	0	0	3.01	2.48	35	0.84

b. Explaining how the data is set up

I set up the data on the basis of two yearly waves given the occurrence of the key explanatory variables, measurement of the individuals' Friendship Group. Each wave is the occurrence of this battery.

First, data from each wave's household file was collapsed to an individual respondents' unique personal ID (using the hhresp and egoalt BHPS files). This produced the household composition of each individual at that specific point in time i.e. whether a particular relative was present. Using the unique personal ID number, the individual level household composition variables were merged with the individual questionnaire data at each wave (the indresp BHPS files) for waves where the battery of questions on the Friendship Group was asked. I then merged this information with the consolidated family history and the non-time

varying data (the family and xwavedat BHPS files). This produced a 'wide' dataset where there were numerous columns of data from each individual.

Secondly, the dataset was transposed into a 'long' format where there were numerous observations (spells) per respondent. I then calculated and dropped spells where the respondent should be excluded from analysis due to age (ensuring the respondent was over 16 and under 40 at the time of the interview) and birth history (ensuring that the interview had taken place at least 9 months before the first birth. The key explanatory binary variable 'a birth within an exposure period of 9-27 months after the interview' was calculated using the difference between the date of the interview for the wave (from the indresp file) and the date of the first birth (from the family file). This variables was coded so that it was 1 if the respondent had a first birth within the 'event window' of 9 and 27 months after the interview, or 0 if the respondent had not had a first birth, or the first birth had occurred more than 27 months after the interview. A theoretical example of the set up of the data set is given in Table Two below, and examples are explained below.

Table 2: Example of 'long' dataset used in the analysis

Row	ID	Age at Wave	First Birth	Wave	Explanatory ß…
1	1	24	0	1	
2	1	26	0	2	
3	1	28	1 (i.e. had first birth within event window, so all subsequent waves dropped)	3	
4	2	20	0	2	
5	2	22	0	3	
6	2	24	0	4	
7	2	26	0	5	
8	2	28	0 (i.e. last interview at 28 still and has not had a child. This individual is right censored)	6	
9	3	37	0	1	
10	3	39	0 (i.e. leaves dataset after this point as over age 40 in subsequent wave)	2	
11	4	23	0	4	
	4	25	(Dropped from analysis. I know that it is 0 this spell but I do not have any explanatory variable information to tie this too)	5	Missing
12	4	27	1 (i.e. had first birth within event window, so all subsequent waves dropped)	6	

ID 1 contributes three spells of data. She enters the dataset at age 24, and does not have a first birth until after the third wave of the study. She then exits the dataset.

ID 2 contributes five spells of data. She enters the dataset at age 20 in the second wave of the study. She does not have a child during the measurement period and is right censored.

ID 3 contributes two spells of data. She enters the data set in the first wave of the study at age 37, she does not have a first birth after this interview or after the second wave interview. She therefore exits the dataset after wave 2 as she is over 40 years of age by wave 3.

ID 4 contributes two spells of data. She is a new entrant at wave 4 when the BHPS sample was expanded in Wales and Scotland. She did not complete an interview questionnaire in wave 5 of the study, but did complete one in wave 6 and has a first birth recorded within 9-27 months of this interview.

2) Individual Socio-Economic Status (SES)

I present results with controls for socio-economic status at the parental level given the young age of some of the respondents. I did considered three different aspects of SES; education, occupation and income. Including all of the individuals SES controls instead of the paternal SES controls, and the results for the key explanatory variables are very similar, though the significance of frequently contacted relatives falls from 5% to 10%. Similar results are seen if the individual level SES controls are included one at a time. Table 3 shows the descriptive information for these variables and Table 4 the effect of the individual SES variables and the key explanatory variables.

Here, and throughout the supplementary material sections, I will for convenience display only a selection of the parameter estimates from the model. Whilst I will only show the estimates that are of interest it should be noted that the models still contain the additional control variables. These are listed below the tables showing the section of regression model output.

Table 3: Descriptive statistics of individual SES variables

Descriptive statistics of other categorical variables	*Number of spells*	*Percentage of spells*	*Percentage of which are followed by a 1st birth*
Education level: University degree or equivalent	893	21.4	7.3
Education level: A level or equivalent	1,293	30.9	6.6
Education level: less than A level qualifications or no recorded qualifications	1,996	47.7	7.8
Current Occupation Registrar-General Classification: Professional / managerial	1,193	28.5	9.5
Current Occupation Registrar-General Classification: Skilled non-manual	1,602	38.3	6.3
Current Occupation Registrar-General Classification: Manual employment	1,020	24.4	8.1
Never Employed	285	6.8	2.1
Occupation Missing	82	2.0	4.9
Descriptive statistics of continuous variables	*Mean*	*Standard Deviation*	
Individuals annual income (£1000s in 2005 equivalent purchasing value, adjusted by Consumer Price Index)	10.1	9.8	
Percentage of household income earned by the respondent	37.5	32.0	

Table 4: Models Eight and Nine including individual level SES controls

	RR	p	RR	p
Number of relatives in friendship group	1.20	0.04		
Number of friendship group contacted 'most days'	1.01	0.88		
Number of relatives contacted 'most days' in friendship group			1.22	0.07
Education level: University degree or equivalent (reference less than A level qualifications or no recorded qualifications)	0.57	0.00	0.58	0.00
Education level: A level or equivalent (reference less than A level qualifications or no recorded qualifications)	0.71	0.03	0.71	0.03
Current Occupation Registrar-General Classification: Professional / managerial (reference Manual employment)	0.82	0.28	0.83	0.31
Current Occupation Registrar-General Classification: Skilled non-manual (reference Manual employment)	0.57	0.00	0.57	0.00
Never Employed (reference Manual employment)	0.64	0.33	0.65	0.34
Occupation Missing (reference Manual employment)	1.27	0.67	1.29	0.66
Individuals annual income (£1000s in 2005 equivalent purchasing value, adjusted by Consumer Price Index)	1.01	0.55	1.01	0.56
Percentage of household income earned by the respondent	1.55	0.26	1.54	0.27

Also controlling for Sibship size, Religiosity, Ethnicity, Respondent lives in Scotland or Wales, Age (with quadratic term), Household composition and Wave of data collection

3) Coefficients model (including intercept)

The interpretation of the exponentiated and non-expoentiated models is very similar. For hypothesis testing the only main difference is that in the exponentiated (Relative Risk) versions a value greater than one indicates the variable has a pro-natal effect, less than one an anti-natal effect. In the non-exponentiated coefficients the difference is around zero, so values greater than zero are pro-natal effects, and less than zero anti-natal effects. The full set of the non-exponentiated regression coefficients is set out in table 5 below.

Table 5: Models Eight and Nine presented with intercept and regression coefficients

	Model Eight		Model Nine	
	Coef	p	Coef	p
Intercept	-6.61	0.00	-6.48	0.00
Number of relatives in friendship group	0.19	0.04		
Number of friendship group contacted 'most days'	0.03	0.65		
Number of relatives contacted 'most days' in friendship group			0.23	0.03
Household contains (ref: Lives alone)				
Partner	1.77	0.00	1.79	0.00
Mum	0.53	0.12	0.52	0.13
Dad	-0.44	0.22	-0.43	0.23
One or more sisters	-0.48	0.19	-0.48	0.19
One or more brothers	-0.01	0.98	-0.01	0.98
One or more non-relatives	-0.52	0.22	-0.51	0.23
One or more other relatives	1.08	0.01	1.10	0.01
Household size (capped at 6)	-0.01	0.98	-0.01	0.95
Ever a member of a religious organisation (ref: Never)	0.13	0.48	0.12	0.50
Non-white ethnicity (ref: white ethnicity)	-0.06	0.88	-0.08	0.84
Internal migration from last wave (ref: No migration)	-0.18	0.54	-0.19	0.53
Internal migration missing	-0.25	0.50	-0.25	0.50
Respondents lives in Scotland (ref: England)	0.32	0.19	0.30	0.22
Respondents lives in Wales (ref: England)	-0.16	0.65	-0.18	0.61
Cambridge Occupation Score of respondent's father	-0.01	0.06	-0.01	0.09
Cambridge Occupation Score of respondent's mother	0.00	0.70	0.00	0.70
Cambridge Occupation Score of respondent's father: missing	-0.48	0.03	-0.47	0.03
Cambridge Occupation Score of respondent's mother: missing	0.21	0.39	0.21	0.37
Number of siblings (capped at 6)	0.07	0.20	0.07	0.17
Number of siblings: missing	-1.17	0.00	-1.15	0.00
Age	0.29	0.01	0.28	0.01
Age^2	-0.01	0.00	-0.01	0.01
Wave1 (ref Wave 6)	0.13	0.54	0.13	0.54
Wave2 (ref Wave 6)	-0.18	0.44	-0.16	0.48
Wave3 (ref Wave 6)	-0.26	0.26	-0.26	0.25
Wave4 (ref Wave 6)	-0.09	0.69	-0.09	0.70
Wave5 (ref Wave 6)	-0.22	0.33	-0.23	0.32

4) Missing data

Missing items are their very nature is difficult to fully explain and control for in quantitative analysis. This section is therefore somewhat speculative. In the models presented in the paper I included a dummy variable for missingness, this is a relatively simplistic approach. I highlighted in the paper it is a concern that paternal occupation missingness is associated with the subsequent (non)occurrence of a first birth.

Of the control variables there were three in particular where missing data was most worrying i) paternal occupation at age 14 ii) maternal occupation at age 14 and iii) sibship size. I will focus on these variables in this section. As set out in the paper, the main source of information that I used to calculate this variable was a direct questions asked at the end of the study (I also used information from the respondents' parents on their number of children to estimate a respondent's siblings). Comparing these variables over time it is clear that there is a negative relationship between time and the proportion missing sibship size. I would speculate that due to attrition fewer respondents from earlier in the study were present at the end of the study, and were thus available to answer these items. In comparison, paternal and maternal occupation have a less clear trend over time. To construct paternal and maternal occupation variables I also used information from several sources. First, the information is included in the non-time varying BHPS file (xwavedat). However, given high levels of missing information here I also used earlier waves of the panel (if the respondents was 14 and their parents' undertook an individual interview).

There are many reasons why parental occupation would not recorded, most simply because the respondent does not know what their parent's occupation was when they were 14. This could be due to a whole range for factors from sporadic employment on the part of the parent, to the absence of the parent from the household either on a short term, long term or permanent basis (i.e. the respondent's parent may have died before the respondent reached 14).

Table 6: Missingness over time

	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5	Wave 6
Total number of observations	805	684	746	677	665	605
% of missing paternal occupation	13.6	15.4	19.0	17.0	16.2	18.9
% of missing maternal occupation	18.3	17.2	18.7	16.3	14.1	15.5
% of missing sibship size	34.9	24.1	19.9	12.3	5.2	3.5

Given these factor is also plausible that many of the control variables used in the model also predicts missingness. For example that lower SES should be associated with higher parental non-employment, absence and mortality. Looking at the bivariate association with education this seems to be the case for all three variables. Respondent have more missing data when they have lower levels of education, here the trend seems to be weaker for those missing sibship size.

Table 7: Missingness by education

	Education level: University degree or equivalent	Education level: A level or equivalent	Education level: less than A level qualifications or no recorded qualifications
Total number of observations	893	1,293	1,996
% of missing paternal occupation	14.4	30.7	54.9
% of missing maternal occupation	19.8	30.3	50.0
% of missing sibship size	22.8	32.4	44.8

As with any binary comparison, it is difficult to make strong conclusions on the relationships observed, as they could be confounded by other variables. I therefore produced multivariate binary logistic models for predicting whether the variable in question was missing in a given spell, using the same control variables as used in main models presented in table 4 (i.e. using individual level SES).

These results are shown in Table 8. Compared to the 'living along' reference category, missing data for all three variables is less likely when the household contains other individuals. Containing a partner had a consistent effect reducing the likelihood of missingness in all three cases, controlling for all other variables. Unsurprisingly the households containing mothers were far less likely to missing maternal occupation, and vice versa with fathers. Slightly surprisingly the presence of siblings in the household did not statistically decrease the likelihood of missing sibship size (though both coefficients are in the expected direction). On the other hand if the spell came from a household where the

respondent lived with non-relatives they were significantly more likely to be missing sibship size (presumably these respondents' families are less likely to also be included in the BHPS sample).

Respondents who reported being religious were more likely to report missing paternal occupation, though less likely to report missing sibship size. On the other hand non-white ethnicity respondents were less likely to report a missing sibship size. In both cases it is rather difficult to explain the reasoning for this. As seen in the bivariate analysis those respondents with higher education qualifications also had the lowest likelihood of missing paternal occupation. However, the effect is not within standard statistical significance for those missing maternal occupation or sibship size. Presumably this can partially be explained as the result of more stable employment, and lower rates of father absence / mortality in higher socio-economic groups.

Both increasing sibship size and having sibship size missing are significantly associated with missing paternal and maternal occupation. Presumably the latter is due to the risk of attrition in the sample, though it is relatively difficult to explain the former.

The age of the respondent at the time of the interview is associated with missing parental occupation for paternal and maternal measures, though the association is non-linear, whereby age first decreases and then increases the likelihood of missingness. This is again rather difficult to explain.

After controlling for the above social and economic variables the effect of the wave of data collection is in opposite directions for likelihood of missing paternal occupation and missing sibship size. There is a positive relationship between wave of study and missing paternal occupation whereby the later waves of the study are more likely to be missing a measure of paternal occupation. For sibship size there is a negative relationship and spells contributed in later waves are less likely to be missing this measure. In summary there are many factors, not all of which that are intuitive, that are associated with missingness.

Table 8 Multivariate models for predicting missingness

	Missing paternal occupation		Missing maternal occupation		Missing sibship size	
Household contains (ref: Lives alone)	Coef	p	Coef	p	Coef	p
Partner	-0.40	0.01	-0.25	0.05	-0.25	0.15
Mum	0.58	0.00	-0.61	0.00	-0.64	0.00
Dad	-1.81	0.00	-0.24	0.08	0.02	0.93
One or more sisters	-0.19	0.17	-0.20	0.12	0.06	0.72
One or more brothers	-0.12	0.36	-0.05	0.67	0.14	0.40
One or more non-relatives	-0.27	0.16	-0.38	0.02	0.63	0.00
One or more other relatives	0.31	0.24	0.15	0.50	-0.06	0.84
Household size (capped at 6)	0.05	0.50	0.14	0.03	0.02	0.78
Ever a member of a religious organisation (ref: Never a member)	0.36	0.00	0.05	0.58	-0.32	0.02
Non-white ethnicity (ref: white ethnicity)	0.10	0.60	0.28	0.11	0.45	0.03
Internal migration from last wave (ref: No migration)	-0.06	0.69	0.01	0.94	-0.16	0.44
Internal migration missing	1.13	0.00	0.62	0.00	1.68	0.00
Respondents lives in Scotland (ref: England)	0.27	0.08	0.04	0.80	0.59	0.00
Respondents lives in Wales (ref: England)	0.11	0.58	0.40	0.02	-0.04	0.88
Education level: University degree or equivalent (reference less than A level qualifications or no recorded qualifications)	-0.34	0.00	-0.06	0.55	0.24	0.09
Education level: A level or equivalent (reference less than A level qualifications or no recorded qualifications)	-0.23	0.01	-0.14	0.07	0.02	0.83
Current Occupation Registrar-General Classification: Professional / managerial (reference Manual)	-0.04	0.71	-0.02	0.86	-0.24	0.10
Current Occupation Registrar-General Classification: Skilled non-manual (reference Manualt)	-0.14	0.15	-0.06	0.47	-0.23	0.05
Never Employed (reference Manual)	-0.09	0.57	0.23	0.14	0.14	0.45
Occupation Missing (reference Manual)	-0.09	0.76	0.33	0.24	0.11	0.81
Individuals annual income (£1000s in 2005 equivalent purchasing value, adjusted by Consumer Price Index)	0.00	0.82	0.01	0.03	0.00	0.88
Percentage of household income earned by the respondent	-0.14	0.57	0.26	0.20	-0.01	0.98
Number of siblings (capped at 6)	0.11	0.00	0.14	0.00		
Number of siblings: missing	0.92	0.00	0.79	0.00		
Age	-0.60	0.00	-0.40	0.00	0.12	0.13
Age^2	0.01	0.00	0.01	0.00	0.00	0.05
Wave1 (ref Wave 6)	-1.63	0.00	-0.43	0.00	2.34	0.00
Wave2 (ref Wave 6)	-1.04	0.00	-0.19	0.11	2.03	0.00
Wave3 (ref Wave 6)	-0.63	0.00	-0.12	0.29	1.64	0.00
Wave4 (ref Wave 6)	-0.59	0.00	-0.17	0.15	1.30	0.00
Wave5 (ref Wave 6)	-0.64	0.00	-0.41	0.00	0.25	0.36

Incorporating this information into a model to predict first birth occurrence and Friendship Group orientation is not straightforward. As I set out on page 48 to attempt to control for the effect of missingness by using imputation by chained equation (Schafer 1995). This process combines numerous multivariate regression models to predict the missing value. It works on the basis that in the non-missing data if the value on variable one is predicted by the value on variable two, then a true value of the missing value on variable one can also be predicted from the non-missing value on variable two. Due to the uncertainty around a missing value it is necessary to simulate several versions of the dataset. I undertook these simulations using the standard Monte-Carlo Markov-Chain approach available in STATA (StataCorp 2009).

I tried to fit imputation models in two ways. First I undertook imputation on a 'long' dataset, as used in the analysis. I used 20 imputation cycles. This generates a dataset of over 90,000 observations. The imputed versions are combined using Rubin's rules, devised to allow for the between and within-imputation components of variation in the regression models parameter estimates (Little and Rubin 2002). Parameter estimates from regression at this stage were in the same expected direction as in the standard regression models. However this approach does not control for the fact that there are multiple entries from the same individual. Whilst this is not considered a problem in discrete-time event history modelling assumptions, it violated the assumptions of chained equation imputation methods (UCLA ATS 2009).

I therefore attempted to conduct imputation at the 'wide' stage, to control for missing values being correlated within individuals. However many individuals did not participant throughout the entire period i.e. some respondents were not interviewed in the early years of the study and some dropped out (sample attrition). Using this method it was not possible to drop non-valid individuals (such as those who at that wave had already given birth). There was therefore a very large amount of missing data in this set up. For example individuals who only contributed one wave of data needed to be kept in, but the imputation would attempt to calculate all of their missing values. The imputation modelling thus failed. I tried using the most reduced model viable. For example using just three variables i) whether the Friendship Group contained a relative, ii) the age at that wave to predict missing value for iii) the number of siblings (non-time varying). Unfortunately this also failed to produce a valid imputed dataset.

As I was unable to implement a satisfactory multivariate approach to handle missing data I remained with the approach set out in the paper, and highlighted its slightly unsatisfactory nature.

5) Using multilevel model control for clustering at household and individual level

It is important to control for differences at the household level. In the models presented I controlled for these household level differences using individual level variables on the household's size and composition. However clustering within households of observations could bias these parameter estimates. In each wave there are a relatively small (though increasing) number of observations from within the same household (Table 9).

Table 9: Bivariate relationship between wave of study and the clustering of observations within the same household

	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5	Wave 6
Total number of observations	805	684	746	677	665	605
Number of observations occurring within the same household	66	119	145	130	158	133
% of observations occurring within the same household	8.2%	17.4%	19.4%	19.2%	23.8%	22.0%

An alternative way to control for household level factors is to include the household as a higher level variable in a multilevel model. Such an approach controls for inter-households variance and therefore reduces the number of control variables required. The explanatory variables from the multilevel household models are set out in Table 10, this again show that the main explanatory variables used as indicators of kin influence have a pro-natal effect.

Table 10: Models Eight and Nine set out as multilevel models including household ID as a higher level variable

	Coef	p	Coef	p
Number of relatives in friendship group	0.48	0.00		
Number of friendship group contacted 'most days'	-0.07	0.31		
Number of relatives contacted 'most days' in friendship group			0.60	0.00

Occupation, Individual's annual income, Sibship size, Education level, Religiosity, Ethnicity, Respondent lives in Scotland or Wales, Age (with quadratic term) and Wave of data collection

One of the key assumptions of discrete-time event history analysis is that there are proportional hazards across time (Box-Steffensmeier and Jones 2004), and so the division of information into numerous spells from the same individuals is not a problem. Instead of using a discrete-time event history analysis and another way to conducted analysis using repeated-measures from the same individual, is to control for this clustering by including the individual as a higher level variable in a multilevel model. The results of the explanatory variables for a model specified in this manner are set out in Table 11, and again show the significance positive effect of relatives' on the propensity to have a first child.

Table 11: Models Eight and Nine including individual ID as a second level variable

	Coef	p	Coef	p
Number of relatives in friendship group	0.19	0.04		
Number of friendship group contacted 'most days'	0.03	0.65		
Number of relatives contacted 'most days' in friendship group			0.23	0.03

Occupation, Individual's annual income, Sibship size, Education level, Religiosity, Ethnicity, Respondent lives in Scotland or Wales, Age (with quadratic term) and Wave of data collection

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a. PAPER TWO

Family and fertility: Kin influence on the progression to a second birth in the British Household Panel Study

Abstract

The aim of this paper is to highlight the utility of inclusive fitness theory for understanding fertility in contemporary low-fertility human populations. It is often highly adaptive for organisms to aid and encourage the reproduction of their relatives. Indeed, particular features of human female life history, such as short birth intervals and the early cessation of female reproduction (menopause), are argued to be evidence that humans are obligate 'cooperative breeders', and require assistance from relatives for optimal reproductive success. Evolutionary anthropologists have so far focussed on measuring kin's influence on reproduction in natural fertility populations. Here I look at the effect in a present-day low fertility population. Previously I found that for contemporary British females the risk of a first birth increases with the number of non-household relatives she describes as emotionally close. I now look at whether kin influence second births using a wider array of measures of kin influence. In this analysis there are two explanatory variables that significantly increase the risk of a female having a second birth: i) increasing the number of frequently contacted and emotionally close non-household relatives and ii) relatives providing childcare. Both effects were measured subject to numerous socio-economic controls. These effects appear to be independent of one another as there was not a significant interaction between the explanatory variables. I therefore conclude that kin do influence the progression to a second birth, and that this influence is due to both the communication and the assistance mechanisms.

Introduction

Darwinian fitness is measured by the relative frequency of one's genes in subsequent generations. An individual can gain fitness through another organism's successful

reproduction, but only if they share genes. The greater the relatedness the more the benefits of cooperation can outweigh the costs. Fitness so defined includes the successful reproduction of both the individual *and* their relatives into a total 'inclusive' measure (Hamilton 1964). Inclusive fitness theory has been vital in understanding the reproductive behaviour of numerous species, most notably the social insects but also various birds and mammals, where the role of relatives is so important that the reproductive strategy of the species is described as 'cooperative breeding' (Cockburn 1998; Clutton-Brock 2002). Hrdy (2006) has argued that humans should also be classified as cooperative breeders and empirical evidence suggests that in high-fertility resource-poor settings the presence of kin is beneficial for Darwinian fitness outcomes; namely child survival (Sear and Mace 2008) and fertility (Mace and Sear 2005; Sear and Coall 2011 though also see Strassmann and Kurapati 2010).

Here I am examining the extent to which humans in a resource-rich contemporary environment have patterns of reproductive behaviour that fit predictions drawn from inclusive fitness theory. There is only a very limited literature on this subject. I am only aware of two previous studies (Kaptijn, Thomese et al. 2010) and my earlier paper, which used the same dataset as that analysed here, the British Household Panel Survey (BHPS). Both of these papers showed that kin seem to have a pro-natal influence, though using rather different measures of fertility; Kaptijn, Thomese et al. (2010) looked at the number of grandchildren whilst I looked at the transition to a first birth. In this paper I therefore look to see if the effect is replicated for another fertility measure, the transition to a second birth.

There are many social and economic factors associated with variations in the speed and likelihood of a contemporary European woman having a second birth (Frejka 2008; Sigle-Rushton 2008). Whilst a plurality of British females have two children by the end of their reproductive life (Smallwood 2002), there remains considerable 'noise' in models that seek to explain birth intervals in contemporary populations (De Jong 1987; Tavares 2010). As fitness is a relative measure, comparative to an organism's competitors, kin can influence fitness in a setting where fertility is low and child survival is extremely high. Indeed because children are discrete units, each additional child in a low fertility environment represents a proportionally higher increase in reproductive success than in a high fertility society.

As set out by Tinbergen (1963) behaviour should be explained at the ultimate level, *why* it occurs, and at the proximate mechanism level, *how* it occurs. Inclusive fitness theory explains the ultimate reason why kin should influence reproduction. The proximate mechanisms by which kin could exert a pro-natal and fitness-enhancing influence can broadly be divided into two categories. First, resources and practical assistance from relatives may reduce the cost of having children and thus encourage further childbearing. Secondly, communications with kin could have the effect of 'priming' relatives to be more pro-natal. These mechanisms are not mutually exclusive but they can theoretically work independently of each other, though the ultimate motivation for both rests on inclusive fitness.

Kin assistance

Kin provide important assistance in resource-poor and natural fertility societies (Hill and Hurtado 1996; Hawkes, O'Connell et al. 1997; Kramer 2005). In these environments relatives can directly influence fertility by enhancing a female's health and thus her fecundity. Kin providing resources directly to the child could also allow earlier weaning and cessation of lactational amenorrhea, which may in turn lead to shorter birth intervals and higher overall fertility. Kin assistance directed towards mothers and offspring is an intuitive reason from a biological perspective. It is the explanation given for how non-human cooperative breeders enhance the reproductive success of their relatives (Cockburn 1998; Clutton-Brock 2002).

Kin assistance that helps childbearing is not confined to natural fertility populations. In resource-rich societies relatives can and do provide important resources, in the form of finances or time (i.e. spending time looking after their relative's children), both of which could reduce the costs of reproduction. Human offspring require extraordinarily high levels investment from others, normally their parents (Gutman 1988; Hurdy 2009). Turke (1989) argues that in societies where kin provide high levels of assistance this reduces the constraints on a parent's childbearing and thus leads to high fertility. Where kinship support is weak then the costs are borne more by the parents and they therefore have fewer children. Turke's theory was based at the macro level but it is equally plausible that at the micro-level within a population those with less kin assistance will

have fewer children. For kin assistance to influence fertility it must be substantial but not universal. Is this the case in contemporary Britain?

Here I will divide kin assistance into two forms; (1) financial resources and (2) time and childcare. In terms of financial assistance from relatives, most of the empirical evidence comes from the intergenerational transfers literature. Attias-Donfut, Ogg et al. (2005) have shown that in contemporary Europe there are substantial financial transfers between family members, there is however substantial variance across countries. In terms of grandparents, virtually all the families in the Millennium Cohort Study reported some financial assistance from at least one grandparent (Hawkes and Joshi 2007). Analysis of two other British datasets (Tan, Buchanan et al. 2010; Clarke and Roberts 2003) shows around 50% of grandparents report 'regularly' providing financial support. Financial kin assistance even if infrequent could be important if it is substantial, and there is some evidence to suggest that due to economic changes the level of kin's financial assistance could in fact be increasing. In 1997 10% of first time house buyers under 30 required informal assistance to purchase their property, but by 2005 nearly 50% had assistance from 'family or friends' (presumably more the former than the latter (Hills 2007)). Inheritance from family members also remains an important source of wealth variance in contemporary Britain (Hills 2009).

On the time and childcare side, most of research in the UK simply classifies non-parental childcare as 'formal' or 'informal', the latter includes friends who lack an inclusive fitness motivation. Formal childcare is childcare that is purchased by parents, employers or taxpayers. The childcare literature covers a wide variety of arrangements, differing in the nature of the childcare (from occasional babysitting to full legal guardianship) and the age and demands of the child. Nevertheless it broadly seems to show that informal childcare provision is substantial in the contemporary UK, though it does varies substantially between sub-groups of the population. For example Smith and Speight (2010) estimate 40% of families with pre-school children now use some 'informal' childcare, though the utilisation of informal childcare is higher for working mothers (Chevalier and Viitanen 2002).

If distinctions are made within informal sources normally the only type of relatives to be separated out are the child's grandparents. But empirical evidence suggests that relatives

other than grandparents are also involved. For example Fergusson, Maughan et al.'s (2008) analysis indicates that around 45% of children in the county of Avon were cared for by a grandparent and 10-15% by other relatives, these figures being stable for children between 8 and 44 months of age. A similar breakdown was seen across the UK (Wheelock and Jones 2002; Gray 2005) and for both working and non-working mothers (Jones 2008; Hansen and Hawkes 2009). Substantial childcare is also seen in studies looking at grandparental time use (Grundy, Murphy et al. 1999; Clarke and Roberts 2003; Hank and Buber 2009; Attias-Donfut, Ogg et al. 2005). The key point is that in all these studies the provision of childcare and other resources by relatives, particularly the child's grandparents, is significant but not universal.

Whilst kin assistance is substantial, is there any evidence that childbearing assistance actually influences reproduction in resource rich settings? Increasing childcare has long been advocated as a way of increasing childbearing in low fertility societies (Myrdal 1945), and it has also been suggested that additional financial support to parents should also have a positive impact on fertility (McDonald 2002). On the formal side empirical evidence (Mörk, Sjögren et al. 2009; Rindfuss, Guilkey et al. 2010) seems to shows that increased formal childcare stimulates childbearing, though formal childcare financial payments do not seem to act as particularly strong pro-natal incentives (Ermisch 1988; Parr and Guest 2010). Turning to the informal side, Coall and Hertwig (2010) argue that informal kin assistance may also have a pro-fertility effect, and thus kin assistance can still be 'closely related' to inclusive fitness success. Unfortunately there seems to have been only limited investigation of whether this is the case. In the US childcare provided by relatives has been shown to increase fertility intentions (Lehrer and Kawasaki 1985). Another American study by Kuziemko (2006) showed that childbearing by sisters in close geographic proximity, though not brothers, increased fertility risk, a result that Kuziemko attributes to sisters sharing childcare and thus reducing the costs of childbearing. Kaptijn, Thomese et al. (2010) found that grandparents providing childcare increased fertility in the Netherlands. However, Sinyavskaya and Tyndik (2010) and Hank and Kreyenfeld (2003) found no effect of informal or kin-provided childcare on second birth progression in Russia and Germany. In terms of other kin-provided resources, Del Boca's (2002) study in Italy suggests that family financial transfers had a positive effect on fertility.

Kin Priming

Kin priming is a potentially independent mechanism that allows relatives to influence the fertility of their relatives. This idea is based on the recent work of Newson, Postmes et al. (2005) and a key component is that it is communication, rather than resources, that influences fertility. An inclusive fitness perspective highlights that it will often be adaptive for relatives to provide information that encourages or primes individuals towards pro-natal sentiments and thus raises fertility. It should be noted that such priming of relatives may, or may not, be overt or conscious. On the one hand parents could explicitly attempt to persuade their adult children to provide them with grandchildren. It could also be much more subtle, with relatives raising conversation topics pertinent to childbearing, leading conversations to more pro-natal conclusions as well as indirectly encouraging decisions (regarding partnership, housing, employment etc) that are more conducive to childbearing. Capturing the full extent of this priming is extremely difficult as it could occur in thousands of small and seemingly insignificant instances, yet when applied repeatedly over many years the combined effect could be substantial. Newson, Postmes et al. (2005) have argued that the cumulative impact is such that the fundamental norms of a society are shaped by whether it is kin or non-kin communication that dominates social interactions.

Kin priming occurs because of our species' extensive capacity to use information (learn) from others (Flinn 1997). Its effect should be considered only *in contrast* to the information provided by non-kin. Inclusive fitness theory would predict non-relatives are, at best, indifferent to an individual's fitness maximisation. Whilst kin priming is less intuitive to evolutionary biologists, in a highly socially complex species such as humans this second proximate mechanism should not be underestimated.

Kin priming does not require the transfer of resources, but it does require communication between relatives. To help explain variance in second birth transitions the amount of communication with kin in contemporary Britain must, like kin assistance, be substantial and variable. This seems to be the case. Frequency of contact with kin varies with numerous factors; such as age (Grundy, Murphy et al. 1999) occupation and education (Grundy and Murphy 2006), geographic proximity (Nolan and Scott 2006), ethnicity (Owen, Mooney et al. 2004) and local area deprivation (Tan, Buchanan et al. 2010) (Nettle 2010). In general, though, contact with kin is substantial,

particularly for mothers with young children. Hawkes and Joshi (2007) looked at those whose own mother was still alive. They found that 65% saw their mother 'at least' weekly and one-fifth 'daily'. Kin contact is not limited to parents and their adult children and it is estimated that 20% of British adults contact a sibling 'at least several times a week' (Murphy 2008).

There is however only limited empirical evidence on whether kin do communicate more pro-natal messages or whether kin contact actually influences fertility. Newson, Postmes et al. (2007) found in role playing experiments those playing the 'mother' role provided more fitness maximising messages than those playing a 'friend' role. Keim, Klarner et al. (2009) found in qualitative social network analysis that kin seemed to provide social pressure on respondents to have children. Axinn, Clarkberg et al. (1994) provide some evidence for direct conscious persuasion as a mother's preferences for grandchildren were correlated with her adult children's preferences for children. However, in Russia Sinyavskaya and Tyndik (2010) found no significant effect for high level of contact with relatives on actualised fertility.

Variance in kin influence

Several factors will affect relatives' expected inclusive fitness 'returns' and this means there will be variation in the extent relatives assist and encourage fertility. Fertility is not the same as fitness. Fitness will not be maximised if an individual has too many offspring and is unable to provide sufficient investment in each child. Kin are therefore expected to have a protective effect on childbearing that is detrimental to total fitness, i.e. stopping premature or excessive reproduction. Previous studies (Kiernan 1992; Russell 1994; Kiernan and Hobcraft 1997; Manlove 1997) have shown that a potential mother's relatives in the UK have an anti-natal effect when analysis is limited to just her early childbearing. However, in my first paper, when analysis is conducted across the whole reproductive age range, kin show a significant pro-natal effect on the risk of first birth.

Whilst it might on occasion be adaptive for kin to show an anti-natal delaying influence on the timing of first birth, in contemporary low fertility populations their influence on second births should be more consistently pro-natal. In such societies there is often a relatively short 'childbearing window' (Rendall and Smallwood 2003; Iacovou and

Tavares 2011) during which additional births are likely to occur. If parents delay too long after their first birth it will become increasingly difficult to have a second child. This is partly because first births are regularly delayed to the point where fecundity may be on the cusp of rapid decline (in 2008 the average age of first birth for a British female was 27.6 years, and over a third of tertiary educated women do not enter motherhood until they are in their 30s (ONS 2009; Rendall and Smallwood 2003)). Secondly, the costs of having an additional child are likely to increase the longer the delay after the first birth. For example, interruptions to a career from childbearing can be condensed or combined, and childcare and resources (clothing, toys etc) can be more easily shared between children close in age. Therefore once parenthood has been initiated if relatives are attempting to increase their fitness through the fertility of individuals to whom they are closely related, from a theoretical perspective I anticipate that their influence for second births should be on average pro-natal, though the effects may depend upon characteristics of the respondent.

However, there is some empirical evidence which suggests that kin influence might be weaker for second births. Relatives may be more effective and/or their encouragement more substantial when they are priming an individual to become ‘a parent’. Qualitative work by Bernardi (2003) and Rizzi and Kertzer (2010) has found that Italian relatives encouraged individuals to have a first birth, but not later order births. In Germany adult geographic proximity to their parents did have a positive effect on first births, but did not significantly influence second births (Hank and Kreyenfeld 2003). It is therefore important to replicate my previous study on kin influencing the transition to first birth, but this time looking at the transition to second birth.

There are several characteristics of the relatives themselves that will influence their motivation and capacity to influence the respondent’s fertility. As relatedness decreases so will inclusive fitness benefits. Foster (2000) has argued that females have a greater psychological predisposition towards nurturing behaviour and thus may find childcare more rewarding. Relatives will also vary in their capacity to provide resources, both time and financial. Females are also less likely to be employed than males (Duffield 2002). In the UK increasing age is associated with increasing wealth (Banks, Oldfield et al. 2002) and decreasing employment (Duffield 2002). In short older and female relatives might be particularly important i.e. the most influential relative may be the

potential child's grandmother(s). Indeed one of the main motivations for evolutionary anthropologists to test the influence of relatives on fitness is to understand the evolution of menopause (Blurton Jones, Hawkes et al. 2002; Hawkes 2003). From a traditional evolutionary perspective it is perplexing that human females evolved to cease reproduction decades before they could expect to die, a physiological feature of our species which is unique amongst primates. One of the more promising explanations is the 'grandmother hypothesis' (Williams 1957) whereby grandmothers may gain greater fitness through helping their children have successful grandchildren rather than by having additional offspring themselves. Whilst grandmothers may be particularly beneficial for fertility, some categories of kin, notably siblings, may actually be in competition for resources and these relatives could instead hinder reproduction. Nevertheless in my previous paper on the transition to first birth, it did not seem to matter which relatives where described as close. So I predict that all relatives will exert a pro-natal effect on the transition to second birth, but it is important to test whether specific categories of relatives are driving any observed effect.

'Alternative' explanations: developmental social norms

My explanation for the relationship between kin and fertility is based on inclusive fitness. Kin are predicted to positively influence fertility as this will normally also increase their inclusive fitness. There are two potential alternative explanations. Any observed associations could be simply representing a selection effect of an unmeasured characteristic of the respondents. First, some respondents may have 'traditional family' values which orientate them to both maintain strong family networks and to have larger families of their own. In effect the explanatory and dependent variables could be merely indicators of an unobserved latent 'traditional family values' trait.

It is important to understand how such variance in pro-family social values could come to exist. Returning to Tinbergen's (1963) schema on ultimate and proximate level explanations; at the ultimate level behaviour needs to be understood in terms of its function (its adaptive value) and its phylogeny (its evolutionary history). At the proximate level the causes of the behaviour include an understanding of ontogeny (development) and the specific mechanisms than induce the behaviour from stimuli in the immediate environment. Misunderstanding of ultimate and proximate causation has

been a long running problem for explanations of human behaviour (Scott-Phillips, Dickins et al. 2011).

The effect of relatives on fertility has so far been discussed with regards to proximate mechanisms (kin assistance and kin priming) operating in the immediate environment. Many species, and particularly humans, have 'developmental plasticity' whereby information from early environments shapes the individual organism's physiological and psychological development (Bateson, Barker et al. 2004; Burgless 2005). It is especially important for human children and juveniles to acquire social information (norms and values) in order to become successful adults (Bjorklund 2007). Juveniles may vary in the extent they are provided with traditional pro-family norms. However, this could also be considered another part of the kin priming mechanism. During development some individuals may be more influenced by non-kin who instil values towards a life course that is not fitness-maximising. Parents and other relatives may induce values that are more fitness maximising. Studies have shown that the level of kin availability in the developmental environment is associated with reproductive behaviour later in life (Belsky, Steinberg et al. 1991; Belsky 2007). In particular that father absence is associated with a faster life history (Nettle, Coall et al. 2010). The relative effect of kin and non-kin priming on the social norms induced during the developmental period could be important, but the role of the developmental environment falls within a kin influence - inclusive fitness explanatory framework: it is another proximate mechanism. In this study I am only able to look at the components of kin influence in a fairly immediate environment. It would be interesting for future research to look at *when* kin priming has the greatest impact on later female fertility.

'Alternative' explanations: personality

Returning to the question of unobserved factors influencing both kin interactions and childbearing, another potential criticism is that the association is simply due to personality. The association seen could be the product of some personality traits inducing both close kin interactions and higher fertility. Again it is important to understand how such variance in personality can occur. Here it could be a by-product of a separate ultimate functional adaptation for the maintenance of behavioural diversity.

Individual level diversity of behaviour can be the product of both ultimate and proximate factors (Buss and Greiling 1999; Brown, Dickins et al. 2011). Within many species it is adaptive for multiple behavioural strategies to co-exist, as the optimal fitness maximising strategy will depend upon the local ecology (resource availability, population density etc) and the frequency of other behavioural traits within the local population (Maynard Smith 1978). As both of these factors fluctuate so should the optimal behavioural strategy and this in turn should lead to the persistence of differences. In non-human species there can be striking differences between the strategies of members of same species and sex (Gross 1996). A good example is the pygmy swordtail, *Xiphophorous nigrensis*, where males undertake either a 'courting' or 'sneaking' copulation strategy (Ryan and Causey 1989; Zimmerer and Kallman 1989). Courting males are larger, take longer to mature and then invest substantially in trying to attract female mates. Sneaks are smaller, mature earlier and chase females to force copulation. The success of either phenotype is dependent upon the local ecology; smaller males swordtails are believed to be at lower risk of predation (Rosenthal, Flores Martinez et al. 2001; Rosenthal, Wagner et al. 2002). The success of each phenotype is also frequency dependent. If the population is dominated by sneaks, then courting males' long maturation period will 'pay off' as they face limited competition in courting and will be able to attract numerous female mates. They will in turn father a disproportional number of offspring. However, if the population is dominated by large courting males, sneaks will gain a relative advantage. Courting males' long maturation period and courting efforts will not be rewarded with additional offspring due to the intensity of the competition between courting males. Additionally if there are few sneaks then there will be less competition when sneaky chase-copulation opportunities do become available. In short, the swordtail population will maintain both the sneak and courting male strategies.

Nettle (2006) has argued the human personality is another form of behavioural diversity which has a similar ultimate adaptive function. Using Costa and McCrae's (1992) five factor[8] approach to personality Nettle sets out that increasing each personality factor may have costs and benefits for an individual's fitness. So just as there are courting and sneaky male swordtails there are extraverted and introverted humans. The net fitness

[8] The factors are Neuroticism, Extraversion, Openness, Agreeableness and Conscientiousness,

success of a personality type will again depend upon local ecology and the frequency of other personality types within the population. For example, high levels of Agreeableness (one of the five 'factors' of personality) should provide the benefit of strong interpersonal relationships but this will be at the cost of increased susceptibility to cheating and manipulation. High levels of Extraversion will induce greater risk taking, if the environment is benign this may well be beneficial, in harsher environments persistent risk taking could carry severe costs. Therefore at the ultimate level, behavioural diversity, mediated through a range of personality types, is expected across a population. It is through differences in personality that the association between kin and fertility could occur.

There is some tentative evidence that personality components influence the frequency of contact with relatives (Asendorpf and Wilpers 1998). Certainly low levels of Openness or Extraversion are likely to limit interactions with 'new' individuals (who are likely to be non-kin). On the other hand high levels of Agreeableness should induce individuals to maintain strong links with their pre-existing social network. So a combination of low levels of Openness and Extraversion with high levels of Agreeableness should be conducive to strong inter-kin relationships.

The links between personality and fertility are less clear and have only recently be subsequent to empirical investigation, though some personality traits do seem to be associated with some aspects of fertility. Using the BHPS Tavares (2010) shows that low levels of Openness and high levels of Agreeableness also have accelerating effects upon a female's first birth, though it is higher levels of Extraversion that have an accelerating effect. Other researchers have also shown an association between personality and fertility (Jokela and Keltikangas-Järvinen 2009; Jokela, Kivimäki et al. 2009; Alvergne, Jokela et al. 2010). Though looking just a Neuroticism it is interesting to note that in rural Senegal (Alvergne, Jokela et al. 2010) and the contemporary UK (Tavares 2010) increasing Neuroticism had a pro-natal effect, whilst in contemporary Finland increasing Neuroticism had an anti-natal effect (Jokela, Kivimäki et al. 2009). It could be the case that personality is associated with complex mating-parenting trade-offs (Trivers 1972; Maynard Smith 1977). Certainly variance in personality could lead to individual level variance in a female's predisposition towards 'nurturing' which has been considered an important determinant of contemporary low fertility (Foster 2000).

Whilst personality was measured in the BHPS I do not included it in my analysis. This is because it was only measured once, several years after the end of my measurement period. Whilst personality is relatively stable across the life course, there are circumstances, such as major life events, that are shown to be associated with changes in personality (Caspi and Roberts 1999; Lang, Reschke et al. 2006). Jokela, Kivimäki et al. (2009). Srivastava, John et al. (2003) have shown that the relationship between personality and fertility can actually occur in the opposite direction, with parenthood increasing Agreeableness and Emotionality scores. Additionally, personality development, like the development of social norms, may be subject to kin influence. Certainly parenting styles influence children's personality development, for example warm parenting increasing Agreeableness (Shiner 2006). If kin can influence personality they should do so in order to induce a personality conducive to their inclusive fitness maximisation.

It is a plausible alternative ultimate explanation that personality differences (due to adaptive behavioural diversity, rather than kin influence) explain any observed pattern between kin indicators and fertility behaviour. Though separating the ultimate and proximate mechanisms here is fraught with difficulties. The incorporation of personality is a new and exciting area in the study of human reproductive behaviour. It would be a fascinating further expansion of this work to explore the links between personality and kin relationships and fertility, and how these three areas interact over time, but such work lies outside the scope of this paper. Before this can be done it is necessary to examine the relationship between kin and fertility.

In summary, my hypotheses drawn from inclusive fitness theory predict that stronger ties with kin will, on average, increase the risk of a second birth. Secondly there may be two proximate mechanism, kin assistance and priming, through which kin could influence a female's transition to second birth. In this analysis I will attempt to distinguish between the effects of these two mechanisms.

Methods

My data come from six waves of the British Household Panel Study (BHPS) between 1992 and 2003[9]. I restrict my analysis to females as the household clustering of the survey will mean that male and female respondents will regularly be partners and so their fertility will be highly correlated; there are also well known reporting problems with male fertility (Greene and Biddlecom 2000). The BHPS is a longitudinal dataset that is broadly representative of the British population. I used discrete-time event history analysis with the dependent 'event' variable being a second birth (Allison 1984; Box-Steffensmeier and Jones 2004). This technique divides a respondent's recorded time into spells, which last for two years and a respondent may contribute more than one spell to the data. The spell length is determined by the frequency with which the key explanatory variables were collected. A respondent enters the dataset once her first child is born. She can exit the dataset in three ways i) her second child is born, ii) she reaches 45 years of age, or iii) she reaches the end of the data collection period (right censoring) without having a second birth. Multivariate binary logistic regression models are then fitted for predictors of the occurrence of a second birth. Event history analysis has long been regarded as a good technique for understanding birth progressions (Newman 1983) since it allows for both time-varying covariates and censorship in the dataset.

An assumption of this technique is that the covariates have a proportional hazard across each spell. I broadly confirmed this assumption is valid for the models presented here (see results pages 111-118 and supplementary material pages 119-137).

Dependent variable

The dependent event variable used was whether or not a second birth occurred within a window of 9-27 months after the respondent was interviewed. This lagged threshold was used to ensure that respondents were not pregnant at the time they reported on the indicators of kin priming and kin assistance. This controlled for a potential confounding effect whereby relatives increased childcare or contact in response to pregnancy. Respondents who were pregnant i.e. had a birth within nine months of the interview, were not included in the analysis. A cut-off of 27 months was used since respondents

[9] Full question wording, methodology and other documentation available at http://www.iser.essex.ac.uk/survey/bhps

may change their contact with kin and their assistance over time. I tested the sensitivity of the analysis by changing the lag for the measurement of the event (2nd birth) to 9-18 and 18-27 months after the interview. The results stay broadly similar (result not shown but available in the supplementary material page 120). As in Paper One temporary and booster sample members are included. Again results should therefore not be taken as strictly representative of the population of Great Britain.

Explanatory variables

My explanatory variables explore kin priming and kin assistance as proximate mechanisms through which kin can influence the transition to a second birth. Kin priming indicators were constructed from responses to a battery of questions asked in alternate waves of the study on the three individuals the respondents was *'closest'* to outside of their household. I will describe these individuals as 'emotionally close' to the respondent. Two key variables were constructed from the responses to this battery i) the number of relatives who were emotionally close and ii) the number of emotionally close relatives who were also contacted *'most days.'* Contact was defined to include *'visiting, writing or by telephone.'* Both variables were shown to be significant predictors of first birth in my previous paper. Comparison between the effects of these two variables will partly indicate the extent of kin priming, as frequently contacted kin will have more opportunities to prime the respondent.

Secondly, I looked for an indicator of kin assistance, specifically with childcare. Respondents were asked *"Which of the following best describes the way you arrange for your children aged 12 or under to be looked after while you are at work?"* The interviewer then coded up to three arrangements from a list of eleven potential coding categories. My third main explanatory variable was constructed as respondents who mentioned *'a relative'* as one of these three forms of childcare. A dummy variable was included for *'formal childcare'* if the respondent mentioned *'at school', 'nanny / mother help', 'day nursery'* or *'childminder'* The final childcare variable included was *'other childcare'* if she was coded as mentioning '*spouse or partner', 'friend'* or *'other'*. These additional childcare variables were necessary to control for the effect of women using childcare in general on fertility. The reference category was set as the occasions when the respondent did not mention anyone else providing childcare. These variables are thus effectively composite variables for being in employment and receiving that type of

childcare, against a reference category of not being employment and not using childcare whilst at work. The reference category is predominately made up of females who were not in employment, though it also includes a small number of individuals who did report undertaking paid employment. A potential weakness of this childcare question is that it only measures sources of childcare whilst the mother is '*at work..*' It will not capture all childcare and of course there is possible variance in how respondents interpreted the notion of 'work' in the question. I return to this issue in the discussion section. For the models presented here I do not distinguish between whether relative childcare was mentioned first, second or third, or whether it was mentioned in conjunction with other methods. There were only a limited number of occasions when the respondent mentioned more than one type of childcare (for more details see supplementary material page 122).

I tested the robustness of the findings for the kin priming variables by running the model again using different operationalisations. First, I used dichotomised versions of the variables i.e. whether the respondent had *any* emotionally close relatives. Secondly, I decreased the threshold for the frequency of contact 'to at least once a week'. Both of these changes produced similar results though there was, as would be expected, some decrease in the significance level (results in supplementary material page 123)

Three additional explanatory variables were constructed. I looked at specific categories of emotionally close relative (e.g. mother, sister etc) to see if they were driving any overall effect. I also looked at whether geographic proximity of emotionally close relatives impacted on their influence. Here I created variables for whether a respondent lived within 50 miles of an emotionally close relative, and within this geographic strata whether the relative was frequently contacted. This allowed further comparison between the proximate mechanisms. Childcare can only be provided *in situ.* So if kin assistance via childcare is the more important mechanism, then relatives who are geographically distant should not positively influence the transition to a second birth. If kin priming is the more important mechanism, then frequently contacted relatives regardless of their geographic location should have a pro-natal effect. Unfortunately the questions on specific relatives and geographic proximity were not asked in one wave of the BHPS (Wave F 1996-1997) and so the number of spells for this part of the analysis was subsequently reduced by a sixth.

Finally, I attempted to use a variable on whether kin provided financial assistance to the respondent. The BHPS asks participants *"I am going to show you four cards listing different types of income and payments. Please look at this card (SHOWCARD 33) and tell me if, since September 1st last year, you have received any of the types of income or payments shown, either just yourself or jointly?"* One of the options listed was *'Payments from a family member not living here'*. Unfortunately there were only 11 occasions (less than 1%) where the respondent reported receiving a payment from a non-household family member. I am suspicious of this measure and I suspect it may severely underreport the true level of financial transfers from relatives. The item on family payments was listed 30th out of 35 items and the majority of the preceding income options were pensions and welfare benefits. This may well induce a 'context effect' (Tourangeau, Rips et al. 2000). First, as the preceding items were on the whole regular and formal payments and this could have induced respondents to disregard irregular informal payments. Secondly, as many of the items were pensions and incapacity benefits, and unlikely to be available to mothers of young children, most of the respondents will be repeatedly answering 'no' to the previous items. This could then set the negative as the default answer and due to fatigue by the time they reach the 30th item respondents are tired of the question and simply stay with the default. Certainly compared to other measurements of kin financial assistance this value for mothers with young children seems implausibly low. The Millennium Cohort Study asked more detailed questions and found that between 75-80% of new parents reported receiving financial help from grandparents (Owen, Mooney et al. 2004). Attias-Donfut, Ogg et al. (2005) estimated that over 50% of older generation Europeans provide financial assistance to their adult children. Unfortunately the limitations of the BHPS measure means it was not possible to analyse whether financial kin assistance was associated with the occurrence of second births.

Respondents were only included within the dataset when they were present in a wave of data collection containing the battery on individuals who were emotional-close to the respondent. If respondents were missing for one wave of data collection they were still eligible to be inclusion in later waves (subject to the usual constrains, such as not being pregnant with a second child).

Control variables

There are numerous factors that influence childcare provision and kin contact and these same factors could also confound any observed association with second birth transition. First, three types of 'time' measurement are included in all of the models. The event history analysis is based on the number of months since the respondent's first birth, and this measure may also reflect the effect of the 'childbearing window' discussed earlier. It also captures the first born child's age and this will correlate with the nature of childcare, as older children are eligible for (pre)schooling. Secondly, the respondent's age is included, as a female's age is associated with both her fecundity and the nature of her family and friend contacts (Pahl and Pevalin 2005). Finally all models include categorical variables for the wave (year) of the survey to take into account calendar time, though their effect is consistently non-significant and so they are not reported.

As set out in the introduction, many social and economic factors influence kin assistance and kin contact. These factors could also confound any observed relationship with fertility, as they may independently influence both kin relations and second birth. Female employment increases childcare demand and at a macro level there is a much commented-upon association with fertility (Engelhardt and Prskawetz 2004). The extent of employment is controlled by the number of reported hours the respondent is in paid employment (including overtime). Education is included as a time-varying covariate though in reality very few of the respondents obtained additional qualifications (for example less than 2% of those without a degree obtained one during this period). It is nevertheless an important control variable. Higher education is often shown to be associated with birth interval length (Rendall and Smallwood 2003), and is also associated with weaker kin interactions (Pahl and Pevalin 2005). Grandparental childcare involvement is also higher for those with lower educational attainment (Fergusson, Maughan et al. 2008). Females with higher education are also more likely to use formal sources of childcare (Jones 2008). Income could also be an important control, as it will influence the capacity to purchase formal childcare in place of informal childcare, and the opportunity costs of leaving the labour force (Becker 1991). Family networks and childcare practices also differ between ethnic-cultural groupings (Bell, Bryson et al. 2005) so does fertility (McQuillan 2004; Coleman and Dubuc 2010).

I therefore included non-time varying controls for religious organisation membership and non-white ethnicity.

I also controlled for household composition, as the explanatory variables on kin contact are with non-household members. Having a resident partner will clearly influence fertility and it also influences grandparental childcare involvement (Clarke and Roberts 2003). As noted before, relatives will not always induce pro-natal influences and in particular they may be anti-natal if adult children are still at the parental home, though this is likely to be more of a factor in postponing the onset of parenthood. I also controlled for the sex of the first born child: this can influence numerous parental behaviours, including fertility and childcare (Lundberg 2005). I included a control variable for sibship size as this would influence the number of non-household relatives who were available for inclusion within the emotionally close relatives measure, and there is also a known correlation between the fertility of parents and offspring (Murphy 1999).

Scotland and Wales are over represented in later waves of the BHPS as their sample was expanded in the late 1990s to allow separate analysis of these countries. I therefore included dummy variables for both countries in the models. Nevertheless the results should not be interpreted as being fully nationally representative as the BHPS does not include an appropriate longitudinal weighting to ensure full representativeness for this type of analysis.

Interactions and non-linear effects

I test two different types of interactions. First, the proportional hazards assumption was broadly confirmed via testing interactions between the time since first birth and all the other variables. Secondly, I looked for significant interactions between the explanatory variables and all the socio-demographic controls variables. This was because the pro-natal (or anti-natal) influence of relatives on fertility could be limited to particular sub-groups in the populations and the observed aggregate effects could mask both pro-natal and anti-natal effects. However, I did not find any consistent interactions between the socio-demographic controls and the explanatory variables that were statistically significant at the 5% level (more details on the above results are set out in the supplementary material page 124-6). Finally I checked for non-linear effects for each of

the continuous variables. A quadratic term was included in the final model for age to control for non-linear effects here, though no other non-linear effects were found to be significant.

All analysis was conducted using STATA 11.

Results

My final dataset contains information from 594 females who had had a first birth. The youngest female in the dataset was 17 and the oldest 44. These women contribute 1115 spells of data. 242 second births were captured in the 9-27 month threshold after the interview meaning that 21.7% of spells ended in a second birth. Compared to the transition to first birth the dataset is smaller though the proportion of spells ending in a second birth is higher. This reflects the 'childbearing window' effect whereby females often proceed to their second birth relatively quickly, certainly compared to the substantial (and increasing) length of time taken between reaching sexual maturity and having a first birth.

Table 1 shows the descriptive statistics for the explanatory variables. It also shows the volatility of the time varying covariates for respondents who contributed data in two or more waves. Descriptive statistics for the categorical and continuous control variables are shown in Table 2 and Table 3 (results tables are on pages 111 - 114).

Column three of Table 1 also shows the percentage of spells that end with a second birth 9-27 months after measurement for each of the categorical variables. The bivariate association is in the expected direction for both the kin assistance and kin priming indicators. As the number of emotionally close relatives increases so does the percentage of spells ending in a second birth (chi-square association significance p=0.050). The same association is seen for those relatives who are also frequently contacted, though it is only marginally significant (chi-square association significance p=0.077). 25% of spells where the relative provides childcare end in a second birth, which is slightly higher than when the respondent does not mention receiving childcare (21%), though this association falls outside of conventional statistical significant (chi-square association significance p=0.116).

Table 4 shows the multivariate discrete-time event history models for the first three explanatory variables included separately but with all the control variables also included. The results are presented as relative risks[10], whereby a value greater than one indicates that this variable increases the risk of a 2nd birth occurring 9-27 months after the interview compared to the reference category (controlling for all other variables) whilst a value less than one indicates that this variable decreases the risk of a 2nd birth. I included all the theoretically relevant control variables in each model though it should be noted that many do not significantly predict the occurrence of a second birth. In a 'best fitting model', produced from backwards model selection, the explanatory variable's effects are still essentially the same as those displayed here (see page 127 supplementary material).

Model one shows that once my control variables have been added the number of emotionally close relatives no longer significantly predicts the occurrence of a second birth. On the other hand, model two shows the number of emotionally close *and* frequently contacted relatives does significantly increase the risk of a second birth. Model three shows that once the full set of controls is included when relatives look after the child whilst the mother is at work there is a statistically significant increase in the risk of a second birth.

Tables 5 shows models four and five, which include main effects for both types of explanatory variables, but not their interaction. The main effects weaken, with the effect for frequently contacted relatives decreasing to 10% marginal significance though a broadly similar pattern remains. Table 6 shows models six and seven and includes an interaction term in addition to both main effects. In both models the interaction term has a non-significant effect, with a very small effect size for the interaction between frequently contacted relatives. This means that there is not a significant multiplicative effect of both kin childcare provision and frequently contacted emotionally close relatives. At this point I would consider concluding that the significant effects of

[10] Throughout the terms 'relative risk' is used in a statistical sense without any negative connotation. Their interpretation is similar to an odds ratio, however the latter term would be inaccurate in this instance due to the relatively high occurrence of second births. For further explanation see Sistrom, C. L. and C. W. Garvan (2004). "Proportions, Odds, and Risk." Radiology **230**(1): 12-19.

frequently contacted relatives (as an indicator of kin priming) and childcare (kin assistance) are independent.

Table 7 shows the bivariate association between the two variables for kin's emotional proximity and relative's provision childcare. It shows that there is a limited association between a respondent having emotionally close relatives and a relative providing childcare (chi-square association significance p = 0. 0.148). However there is a significant relationship with frequently contacted emotionally close relatives (chi-square association significance p = 0.022). This suggests that at least some of the relatives who are providing childcare are also emotionally close and in frequent contact with the respondent.

I also analysed two other sets of explanatory variables and their bivariate association with the occurrence of a second birth is also shown in Table 1. A summary of the results of their multivariate models are set out in Table 8. This table only contains the results of the explanatory variables though the full set of control variables was used in all of these models. I have only shown the explanatory variables because the controls provided very similar results to those already seen. As noted above the sample size was reduced by one–sixth for the analysis of these variables. However, in this reduced dataset the same pattern was seen for the explanatory variables as described above (i.e. when included separately, variables for i) childcare provided by relatives and ii) the number of frequently-contacted emotionally close relatives, both significantly predicted the occurrence of a second birth at the 5% level).

I looked at the effect of a respondent being emotionally close to a specific relative (mother, sister etc). The two most commonly cited relatives were mothers, included in 29% of spells, and sisters, included in 27%. From Table 1 there appears some variation in the bivariate association between the specific relatives reported and whether the respondent has a subsequent second birth, though *all* of the specific relative categories were followed by a higher than average percentage of spells ending in a second birth. I included the presence of a specific relative as the sole explanatory variable in a multivariate model and in all cases the presence of the specific relative was in the anticipated direction (it increased the risk of a second birth), though the effect was never statistically significant. This suggests that the aggregate effect of emotionally close

relatives was not driven by the presence of one particular type of relative. Unfortunately the BHPS does not provide information on which relatives are providing childcare, so I was unable to explore this aspect further. Though the literature suggests it would be largely, though not exclusively, grandparents.

Finally, I analysed an interaction between geographic proximity and frequent contact with emotionally close relatives. There were only 19 occasions when respondents lived over 50 miles away and also contacted an emotionally close relative 'most days,' so I made a single group for occasions when the relative lived over 50 miles away. In my previous first birth paper emotionally close relatives only had a significant effect when they lived within 50 miles of the respondent *and* were also contacted frequently. In contrast when looking at second births geographic proximity does not seem to be a major factor in determining kin influence. In Table 1 the bivariate relationship indicates that it was actually those on occasions an emotionally close relative lived *further away* that there was a significant association with subsequent second birth occurrence (chi-square association significance $p = 0.026$). Though the extract of the full multivariate model presented in Table 8 shows that the geographic proximity of relatives was not statistically significantly associated with the occurrence of a second birth once the full range of socio-demographic controls had been included. Kin who are geographic closer could more readily provide childcare, so the lack of a difference between these variables add some support to the idea that kin influence's is not solely due to their assistance with childcare.

Discussion

These results suggest that kin positively influence the progression from first to second birth in the contemporary UK. This is one of the first times that an explicitly evolutionary minded test of the influence of relatives on fertility has been undertaken in a resource-rich and low-fertility setting (the others being my first paper and Kaptijn, Thomese et al's 2010 paper). The risk of a second birth was significantly increased by both the number of frequently contacted emotionally close relatives and by having a relative provide childcare. However, unlike its effect upon the risk of a first birth, the number of emotionally close relatives (regardless of their frequency of contact) did not significantly increase the risk of a second birth. The effect of this variable was,

however, in the same direction in both sets of analysis, and the non-significance in the second birth model could be due to fewer observations.

A second more tentative conclusion from the observed associations is that both proximate mechanisms, kin assistance and kin priming, have an effect. However, only very cautious conclusions on the relative importance of the proximate mechanisms should be drawn. First, relatives who help with childcare can also encourage and prime the respondents to have an additional child. I am not able to match the relatives in the two indicators together, but there is a significant bivariate association between respondents reporting frequent contact with emotionally close relatives and a respondent reporting that her first born child is looked after by a relative. Secondly, the temporal relationship between kin priming and kin assistance is unclear. Are relatives in close social proximity simply more likely to undertake childcare, or does the provision of childcare bring relatives closer together?

Limitations

In this analysis I am using indicators of kin priming and kin assistance, and there are limitations in the extent that these concepts are fully captured. First, they are only measured in the immediate environment prior to birth. Kin priming could be induced by relatives other than the three the respondent considers particularly close at that point in time. Kin assistance can be much more substantial than simply the provision of childcare whilst the respondent is 'at work,' which is unfortunately a caveat of the question. I am not able to identify which relatives are providing childcare. Whilst none of the categories of specific emotionally close relatives (mother, sisters etc) were significant, all had positive effects and non-significance could again simply be due to an insufficient number of observations. Both concept measures require subjective classification of who is a 'relative' and thus could include social relatives, such as step-parents or adopted siblings, as well as the genetic ones relevant for inclusive fitness theory. The BHPS was designed as a multipurpose survey, without my research question in mind. Many of the above problems are simply a limitation of using data of this nature. Nevertheless the BHPS is a good dataset in many other ways, providing broadly representative and longitudinal information. It has allowed me to show that there is a significant association between kin interactions and fertility, even after numerous socio-economic controls.

Inclusive fitness theory predicted the association that I found. However as I set out in the introduction to this paper, there are other theoretical explanations, notably personality variance, which could potentially also explain these results. Inclusive fitness theory gave a relatively clear a priori theoretical reason to expect kin to have a positive influence on second births, whilst the relationship between fertility, kin and personality is a far more complicated. More research is needed to tease out the roles of kin influence and personality, and as I set out in the introduction it will be difficult to completely separate out the effect of kin upon personality.

I therefore argue that the key conclusion from these results is that in a resource-rich low-fertility setting inclusive fitness theory does seems to predict the pattern of observed fertility behaviour: a mother with a young child who scores highly on indicators of kin assistance and kin priming has a higher propensity in a given period of time following her interview to have a second birth. This paper complements my earlier work which showed the influence of kin on the transition to first births. Both papers address a gap in the literature. Social scientists have long been interested in fertility and family structure (Davis and Blake 1956; Young and Wilmott 1957). However there has been relatively little contemporary social science research on if and how family influence fertility in resource-rich societies. The use of theory developed in evolutionary biology to explain human behaviour has been controversial (Laland and Brown 2002). However, I believe the results shown demonstrate the utility of an evolutionary biology - inclusive fitness perspective when seeking to understand contemporary family and fertility behaviour.

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Table 1: Descriptive statistics of explanatory variables

Descriptive statistics of explanatory and categorical variables	*Number of spells*	*% of spells*	*% spells followed by a 2nd birth*	*% individuals who ever change value*[11]
Number of emotional close relatives (used as a continuous variable)				
0	439	39.37	18.68	31.07
1	445	39.91	22.02	41.79
2 (or 3)	231	20.72	26.84	23.21
Number of frequently contacted friends (used as a continuous variable)				
0	353	31.66	24.65	41.43
1	374	33.54	19.79	54.29
2	251	22.51	22.31	43.57
3	137	12.29	18.25	26.43
Number of emotionally close relatives contacted 'most days' (used as a continuous variable)				
0	711	63.77	19.69	37.50
1	291	26.10	24.40	40.00
2 (or 3)	113	10.13	27.43	17.14
Childcare variables				
Does not use childcare (reference)	424	38.03	21.23	33.93
Has a relative providing childcare	275	24.66	25.09	31.43
Has childcare provided from a 'formal' source	396	35.52	21.72	41.43
Uses another form of childcare	251	22.51	18.33	37.14
If the specific relative mentioned below is emotionally close too				
A parent	280	30.53	26.43	21.07
Her mother	267	29.12	27.34	21.07
Her father	40	4.36	27.50	4.64
A sibling	281	30.64	23.84	19.29
A sister	252	27.48	24.21	16.79
A brother	36	3.93	27.78	4.29
An 'other relative'	96	10.47	23.96	10.00
A relative is emotionally close but lives over 50 miles away	105	11.45	30.48	11.79
A relative is emotionally close, lives within 50 miles but is infrequently contacted	199	21.70	21.61	25.36
A relative is emotionally close, lives within 50 miles of the respondent and is contacted 'most days'	299	32.61	25.08	28.57

[11] *If the individuals provides information in two more waves*

Table 2: Descriptive statistics of categorical control variables

	Number of spells	*% of spells*	*% spells followed by a 2nd birth*	*% who ever change value*[12]
First born child is female	546	48.97	22.34	n/a
Number of siblings (used as a continuous variable)				
0	259	23.23	18.53	n/a
1	334	29.96	24.85	n/a
2	264	23.68	21.21	n/a
3	149	13.36	22.82	n/a
4	47	4.22	25.53	n/a
5 or more	62	5.56	14.52	n/a
Sibship size: Missing	133	11.93	15.79	n/a
Education level: University degree or equivalent	199	17.85	31.66	1.79
Education level: A level or equivalent	237	21.26	21.94	4.64
Education level: Less than A level or missing (reference)	670	60.09	18.96	2.86
Ever been a member of a religious organisation	190	17.04	27.89	n/a
Non-white ethnicity	43	3.86	18.60	n/a
Respondent lives in England level (reference)	963	86.37	21.70	0.36
Respondents lives in Scotland	99	8.88	21.21	0
Respondents lives in Wales	53	4.75	22.64	0.36
Household contains				
No other adults (reference)	229	20.54	10.92	20.00
A partner	801	71.84	25.59	21.43
A sibling	48	4.30	14.58	4.64
A parent	89	7.98	12.36	9.64
Another adult	23	2.06	21.74	3.93

[12] *If the individuals provides information in two or more waves*

Table 3: Descriptive statistics of continuous variables

	Mean	*Standard Deviation*
Time employed, including overtime (hours)	18.659	17.279
Individuals annual income (£1000s in 2005 equivalent purchasing value, adjusted by Consumer Price Index)	9.993	8.836
Percentage of household income earned by the respondent	46.130	33.745
Time since 1st birth (months)	43.879	33.725
Age (years)	30.431	6.073
Number of individuals in the household (capped at 6)	2.968	0.756

Table 4: Multivariate results - explanatory variables main effects

	Model 1		Model 2		Model 3	
	RR	*p*	RR	*p*	RR	*P*
Number of emotionally close relatives	1.140	0.233				
Number of frequently contacted friends	1.025	0.773				
Number of frequently contacted emotionally close relatives			1.262**	0.045		
Childcare provided by a relative (ref: Does not use childcare)					1.604**	0.018
Formal childcare used (ref: Does not use childcare)					1.496*	0.051
Other form of childcare use (ref: Does not use childcare)					0.733	0.143
First born child is female	1.118	0.486	1.117	0.492	1.119	0.486
Time employed, including overtime (hours)	0.997	0.655	0.997	0.641	0.990	0.169
Individual's annual income (£1000s 2005 CPI equivalent)	1.010	0.478	1.010	0.454	1.009	0.522
Percentage of household income earned by respondent	0.993	0.137	0.993	0.128	0.993	0.156
Sibship size, capped at 5	0.976	0.722	0.983	0.793	0.984	0.806
Sibship size: Missing	0.643	0.157	0.652	0.169	0.666	0.195
Education level: University degree or equivalent	1.747**	0.012	1.788***	0.009	1.731**	0.014
Education level: A level or equivalent	0.877	0.529	0.891	0.58	0.857	0.46
Respondents who have ever attended religious organisations	1.423*	0.089	1.424*	0.088	1.434*	0.084
Non-white ethnicity	1.081	0.866	1.093	0.847	1.101	0.835
Respondents lives in Scotland (ref England)	1.041	0.888	1.036	0.9	0.991	0.974
Respondents lives in Wales (ref England)	1.149	0.709	1.144	0.716	1.090	0.816
Household contains (ref Lives Alone)						
A partner	1.978	0.158	1.991	0.155	2.125	0.122
A sibling	2.315	0.238	2.348	0.232	2.465	0.21
A parent	0.735	0.661	0.713	0.629	0.630	0.514
Another adult	1.752	0.385	1.709	0.406	1.877	0.336
Number of individuals in the household (capped at 6)	0.682	0.167	0.688	0.179	0.680	0.174
Time since 1st birth (months)	0.984***	0	0.984***	0	0.983***	0
Age (years)	1.701***	0.001	1.687***	0.001	1.679***	0.001
Age (years squared)	0.990***	0	0.990***	0	0.990***	0
Pseudo – r squared	*0.1346*		*0.1365*		*0.1433*	

Controlling for wave of data collection (non-significant in all models)

***p <0.01; **p <0.05; *p<0.1

Table 5: Multivariate results - explanatory variables in a combined model

	Model 4		Model 5	
	RR	*p*	RR	*p*
Number of emotionally close relatives	1.138	0.244		
Number of frequently contacted friends	1.009	0.921		
Number of frequently contacted emotionally close relatives			1.231*	0.08
Childcare provided by a relative (ref: Does not use childcare)	1.598**	0.019	1.545**	0.03
Formal childcare used (ref: Does not use childcare)	1.514**	0.045	1.535**	0.039
Other form of childcare use (ref: Does not use childcare)	0.747	0.172	0.760	0.197
Interaction: Number of emotional close relatives * Childcare provided by a relative				
Interaction: Number of frequently contacted emotional close relatives * Childcare provided by a relative				
First born child is female (ref: male)	1.128	0.457	1.125	0.467
Time employed including overtime (hours)	0.990	0.171	0.990	0.166
Individual's annual income (£1000s 2005 CPI equivalent)	1.010	0.497	1.010	0.476
Percentage of household earned by individual	0.993	0.144	0.992	0.132
Sibship size capped at 5	0.975	0.713	0.982	0.786
Sibship size: Missing	0.651	0.174	0.663	0.191
Education level: University degree or equivalent (ref: less than A level)	1.739**	0.014	1.776**	0.01
Education level: A level or equivalent (ref: less than A level)	0.857	0.462	0.870	0.506
Ever a member of a religious organisation (ref: never a member)	1.433	0.085	1.433	0.085
Non-white ethnicity (ref: white ethnicity)	1.090	0.854	1.103	0.833
Respondents lives in Scotland (ref: England)	1.007	0.981	1.011	0.969
Respondents lives in Wales (ref: England)	1.113	0.774	1.111	0.777
Household contains (ref lives alone)				
A partner	2.052	0.141	2.069	0.136
A sibling	2.512	0.2	2.532	0.197
A parent	0.655	0.552	0.638	0.526
Another adult	1.887	0.334	1.827	0.359
Number of individuals in the household (capped at 6)	0.677	0.167	0.683	0.181
Time since 1st birth (months)	0.983***	0	0.983***	0
Age (years)	1.673***	0.001	1.664***	0.001
Age (years squared)	0.990***	0	0.990***	0
Pseudo – r squared	*0.1445*		*0.1459*	

Controlling for wave of collection (non-significant in all models)

***p <0.01; **p <0.05; *p <0.1

Table 6: Multivariate results - explanatory variable interactions

	Model 6		Model 7	
	RR	*p*	RR	*P*
Number of emotionally close relatives	1.060	0.651		
Number of frequently contacted friends	1.002	0.985		
Number of frequently contacted emotionally close relatives			1.227	0.155
Childcare provided by a relative (ref: Does not use childcare)	1.282	0.394	1.537*	0.086
Formal childcare used (ref: Does not use childcare)	1.513**	0.046	1.534**	0.04
Other form of childcare use (ref: Does not use childcare)	0.750	0.179	0.760	0.198
Interaction: Number of emotional close relatives * Childcare provided by a relative	1.279	0.295		
Interaction: Number of frequently contacted emotional close relatives * Childcare provided by a relative			1.009	0.972
First born child is female (ref: male)	1.117	0.496	1.125	0.468
Time employed included overtime (hours)	0.990	0.168	0.990	0.166
Individual's annual income (£1000s 2005 CPI equivalent)	1.009	0.536	1.010	0.477
Percentage of household earned by individual	0.993	0.164	0.992	0.133
Sibship size capped at 5	0.975	0.709	0.982	0.785
Sibship size: Missing	0.644	0.164	0.662	0.191
Education level: University degree or equivalent (ref: less than A level)	1.711**	0.017	1.775**	0.011
Education level: A level or equivalent (ref: less than A level)	0.857	0.461	0.870	0.506
Ever a member of a religious organisation (ref: never a member)	1.425	0.09	1.434	0.085
Non-white ethnicity (ref: white ethnicity)	1.055	0.909	1.101	0.836
Respondents lives in Scotland (ref: England)	0.993	0.98	1.011	0.97
Respondents lives in Wales (ref: England)	1.093	0.812	1.110	0.779
Household contains (ref lives alone)				
A partner	2.109	0.127	2.070	0.136
A sibling	2.597	0.185	2.534	0.196
A parent	0.681	0.59	0.638	0.528
Another adult	1.943	0.314	1.828	0.358
Number of individuals in the household (capped at 6)	0.669	0.157	0.683	0.18
Time since 1st birth (months)	0.983***	0	0.983***	0
Age (years)	1.679***	0.001	1.664***	0.001
Age (years squared)	0.990***	0	0.990***	0
Pseudo – r squared	*0.1455*		*0.1459*	

Controlling for wave of collection (non-significant in all models)

***p <0.01; **p <0.05; *p <0.

Table 7: Bivariate relationship between number of family in friendship group and relative provision of childcare

		Childcare provided a relative
Number of relatives in the friendship group (used as continuous variable in model)		
0	N	118
	% (i.e. of those with no emotionally close relatives who have childcare provided by a relative)	*26.88*
1	N	96
	%	*21.57*
2 / 3	N	61
	%	*26.41*
Number of relatives in the friendship group who was contacted 'most days'		
0	N	157
	%	*22.08*
1	N	82
	%	*28.18*
2 / 3	N	36
	%	*31.86*

Table 8: Multivariate results – other explanatory variables

Model	Explanatory variable	RR	*p*
If the specified relative is emotionally close			
8	A parent	1.133	0.500
9	Mother	1.207	0.312
10	Father	1.455	0.352
11	A sibling	1.226	0.284
12	A sister	1.274	0.215
13	A brother	1.275	0.561
14	An 'other relative'	1.061	0.831
Reference category for above models (8-14): *Does not describe that relative as emotional close*			
Geographic distance, frequency of contact and emotional close relatives			
15	A relative is emotionally close but lives over 50 miles away	1.330	0.278
	A relative is emotionally close, lives within 50 miles but is infrequently contacted	0.949	0.808
	A relative is emotionally close, lives within 50 miles of the respondent and is contacted 'most days'	1.291	0.178
Reference category for above model (15): *Does not describe any relatives as emotional close*			

Each model is a separate multivariate regression controlling for the same control variables as used in Models 1-7 but only the results for the explanatory variable are displayed above. Each model included a single explanatory variable(s). All other control variables were included in all of the models. Specifically the control variables used were; First born child is female, Time employed includes overtime, Individual's annual income, Percentage of household income earned by respondent, Sibship size, Education level, Religiosity, Ethnicity, Respondent lives in Scotland or Wales, Household composition, Time since 1st birth, Age (with quadratic term) and Wave of data collection

Note all the above models exclude Wave 3 n=917.

Supplementary Material to Paper Two 'Family and fertility: Kin influence on the progression to a second birth in the British Household Panel Study'

Several additional analyses were performed to test features of the models (assumptions, interactions etc), which have relevance to the issues discussed in the paper, but which are not appropriate to include in a journal article for reasons of space. These additional analyses are described here.

I will start by discussing analysis referred to in the paper in the order in which it is mentioned. I will then discuss several other sections of analysis that were not mentioned but are of relevance for the conclusions that the paper draws. Throughout this section I will present extracts from the multivariate models that were constructed in the same way as those shown in the paper and which included the full set of control variables described in the paper, but I will not display the results for the full set of these control variables (except in part 1.7 which explicitly looks at the effect of the explanatory variables in a reduced 'best fitting' model with fewer control variables). The control variables only change very slightly and this is the same approach adopted for the results displayed in Table Eight in the paper. I focus on the main effects of the three key explanatory variables used in models 1-3: i) the number of emotionally close relatives, ii) the number of frequently contacted emotionally close relatives and iii) childcare provision by a relative. Throughout the standard convention of highlighting significance will be employed using * for 10%, ** for 5% level and *** for 1% statistical significance. Most of this work is 'sensitivity analysis' as it shows that changes in the model parameters or the specification of the variables does not substantially alter the results i.e. the results are not sensitive to operationalisation modifications. Throughout effect sizes will be shown as RR (relative risk).

1 Additional analysis mentioned but not shown in the paper

1.1 Proportional hazards assumption

I checked the validity of the proportional hazards assumption using both continuous (as used in the paper) and categorical versions of the 'time since first birth' variable. In the paper I state that I 'broadly' confirm this assumption as there was one

marginally significant effect that showed an interaction with time since first birth when included in the model as a continuous variable. The interaction between age and time since first birth suggests that as the time since the first birth increased the risk of having a second birth fell away more sharply for older women than for younger women. This is unsurprising, and is likely to partially reflect the decreasing fecundity of older females. Including this interaction has a negligible effect upon the explanatory variables, and given the marginally significant nature of this effect, I decided not to include it in the final models. Models S1 – S3 below show the main effects of the explanatory variables including the proportional hazard interaction in the model.

Table 1: Including an interaction between age and time since first birth

	Model S1		Model S2		Model S3	
	RR	*P*	RR	*P*	RR	*P*
Number of emotionally close relatives	1.16	0.178				
Number of frequently contacted emotionally close relatives			1.28**	0.034		
Childcare provided by a relative (ref: Does not use childcare)					1.59**	0.019
Formal childcare used (ref: Does not use childcare)					1.48*	0.057
Other form of childcare use (ref: Does not use childcare)					0.74	0.163
Interaction: Time since 1st birth (months) * Age (years)	0.99*	0.057	0.99*	0.054	0.99	0.104
Time since 1st birth (months)	1.02	0.263	1.02	0.255	1.02	0.421
Age (years)	1.57***	0.005	1.55***	0.006	1.57***	0.005
Age (years squared)	0.99***	0.004	0.99***	0.005	0.99***	0.003

A full set of control variables are included in the above models though they are not displayed

1.2 Event window

I also state in the paper that the results stay 'broadly' similar if the threshold for measurement of the event (a second birth) birth is changed. The results are displayed in Table 2 below. The first column summarises the results where a birth is counted when it occurred 9-27 months after the interview i.e. the model included in the paper. The second and third columns show the effect when the window for the event is changed to 9-18 and 18-27 months after the interview. This sensitivity analysis tests how robust the results are to changing the window for the event. The last three rows

of the table show the results of multivariate models for the main effects of the key explanatory variables.

The results using alternative event windows generally support those presented in the paper. Though it seems to be the case that the effect of kin providing childcare becomes relatively stronger as the window for the second birth moves closer to the interview (when data on relatives was collected). The effect of the emotionally close relatives (frequently contacted or not) becomes relatively stronger when the threshold is moved further away from the interview. A possible reason for this is that childcare arrangements may change more than communication patterns, so 27 months after the interview the respondent may have different childcare arrangements, though if she contacts her kin frequently originally then she continues to do so. However, the descriptive results shown in the last column of Table One of the paper (page 111) do not show major differences between these two explanatory variables' volatility over time. I return to the issue of the long term effects of emotionally close relatives in section 2.3.

Table 2: Changing the window for the measurement of an occurrence of a second birth

Months after interview during which a 2nd birth is counted	9-27 (Used in the paper)	9-18	18-27
% end in 2nd birth	22%	11%	12%
RR Number of emotionally close relatives (p value in parenthesis)	1.14 (0.233)	1.03 (0.831)	1.31* (0.065)
RR Number of frequently contacted emotionally close relatives	1.26** (0.045)	1.16 (0.322)	1.33** (0.057)
RR Childcare provided by a relative	1.604** (0.018)	2.06*** (0.004)	1.22 (0.449)

A full set of control variables are included in the above models though they are not displayed

1.3 Childcare Mix

In the paper I do not look into complex childcare arrangements where the respondent uses more than one type of childcare. This could have been theoretically interesting in terms of interactions between different types of provisions in the 'childcare jigsaw.' If relatives are used in conjunction with formal childcare it might dilute their impact, and so one potential hypothesis would be that respondents' who use non-kin based support have a lower risk of a second birth. Alternatively, childcare is only measured on a binary basis by the BHPS i.e. whether or not the respondent uses a particular form. There is not a measure of the total amount of support provided by external sources. If a respondent reports numerous childcare providers this might be an indicator of substantial assistance with childcare which could be hypothesised to have a pro-natal effect. Unfortunately as set out in Table 3 below there were only 208 (19%) spells where the respondent mentioned multiple childcare types. The insufficient numbers of spells prohibited detailed separate analysis of interactions between the childcare types.

Table 3: Frequency of the different childcare combinations

Relative childcare	Formal Childcare	Other Childcare	Number of spells	%
No	No	No	424	38.0
Yes	No	No	121	10.9
No	Yes	No	249	22.3
Yes	Yes	No	70	6.3
No	No	Yes	113	10.1
Yes	No	Yes	61	5.5
No	Yes	Yes	54	4.8
Yes	Yes	Yes	23	2.1

As noted early the childcare question is asked on the basis of when the respondent is 'at work'. There were only 10 occasions where the respondent report working any hours in paid employment and did not report using one of these forms of childcare, there were a further 39 occasions when the respondent reported receiving one of these forms of childcare whilst not being in work. As I state in the paper these variables are thus effectively composites for being in employment and receiving that type of childcare, against a reference category of not being employment and not using

childcare (whilst ‘at work’). Dropping these 49 spells very marginally reduces the effect size of the key explanatory variable though their level of significance remains the same, except in model 5, where both explanatory just fall out of standard significance (5%) into the 10% category, and in model 7 where the effect sizes are similar but both main effects now fall just outside of 10% significance (though the interaction term remains high non-significant).

1.4 Thresholds for the explanatory measures

I state that for sensitivity analysis purposes I considered different thresholds for the explanatory variables. Here I test whether the results change if the variables are included in the model as i) dichotomous versions (i.e. whether the respondent had any emotionally close relatives) and ii) with a lower threshold for frequency of contact (reduced from ‘most days’ (the most frequent category) to ‘at least once a week’ (the second most frequent answer available). The results of this section of sensitivity analysis are set out below. The risk of having a second birth is consistently in the predicted direction but due to the decreasing sensitivity of the indicators there are slight decreases in effects sizes and levels of significance.

Table 4: Different thresholds for the explanatory variables

	RR	p value
The number of emotionally close relatives contacted ‘at least once week’ (Model S10)	1.17	0.139
Any emotionally close relatives (S11)	1.12	0.492
Any emotionally close relatives contacted ‘most days’ (S12)	1.34*	0.076
Any emotionally close relatives contacted ‘at least once week’ (S13)	1.14	0.432

A full set of control variables are included in the above models though they are not displayed

1.5 Effect of wave of data collection / calendar time

I included categorical variables for the wave (year) of the interview to take into account calendar time. As they were consistently non-significant they are not reported in the paper. At the national level the Total Fertility Rate was slightly decreasing between 1992 and 2003, though this is not seen in the risk of progression to a second birth once all other factors are controlled for in the model. I have included this information to highlight that a single parity progression should not been seen as analogous to the national level TFR.

Table 5: Effect of wave of data collection on the risk of a second birth

	n (spells)	RR	p value
Wave B 1992-1993	220	1.15	0.64
Wave D 1994-1995	198	1.02	0.937
Wave F 1996-1997	198	0.91	0.755
Wave H 1998-1999	167	1.19	0.562
Wave J 2000-2001	183	1.07	0.82
Wave L 2002-2003	149	Ref	Ref

Extract from full model for Model 3 in the paper. Result for all the other variables are presented in the paper.

1.6 Interactions between explanatory variables and control variables

In the paper I state that I did not find any ‘consistent’ interactions between the explanatory and control variables. I did however find some evidence that emotional close relatives had a significant pro-natal effect for tertiary educated respondents (see model S14 below). This was not seen for frequently contacted relatives, though there were some marginally significant interactions between this variable and respondents holding A level qualifications, but not a degree. There was not any evidence that education level mediated the relationship between relatives helping with childcare and the respondent’s risk of a second birth. Combining both the A level and tertiary educated categories and running the models again (models S16, S19 and S22) produces a similar pattern of results.

These interactions do not substantially change the underlying conclusions of the paper as they were primarily based on frequently contacted emotionally close relatives and childcare provided by a relative. I have included this information here as it is plausible that the kin priming mechanism might have a greater effect on women with more human capital. This is because such women will have better career opportunities and thus will be faced with stronger ‘competing preferences’ instead of having an additional child, and so kin’s persuasion could be all the more important. This could be an interesting area for further expansions of research into kin’s influence on fertility.

Table 6: Interactions between explanatory variables and education variables

Model		RR	p
S14	**Number of emotionally close relatives**	1.00	0.987
	Interaction: University degree or equivalent * Number of emotionally close relatives	1.94**	0.015
	Education level: University degree or equivalent	0.97	0.931
	Education level: A level or equivalent	0.88	0.532
S15	Number of emotionally close relatives	1.07	0.578
	Interaction: Education level: A level or equivalent * Number of emotionally close relatives	1.36	0.235
	Education level: University degree or equivalent	1.73**	0.014
	Education level: A level or equivalent	0.66	0.196
S16	Number of emotionally close relatives	0.88	0.361
	Interaction: A level or higher education * Number of emotionally close relatives	1.88***	0.004
	Combined A level or higher education	0.66	0.118
S17	**Number of frequently contacted emotionally close relatives**	1.22	0.118
	Interaction: University degree or equivalent * Number of frequently contacted emotionally close relatives	1.20	0.548
	Education level: University degree or equivalent	1.65**	0.05
	Education level: A level or equivalent	0.89	0.572
S18	Number of frequently contacted emotionally close relatives	1.14	0.334
	Interaction: Education level: A level or equivalent * Number of frequently contacted emotionally close relatives	1.59*	0.087
	Education level: University degree or equivalent	1.74**	0.013
	Education level: A level or equivalent	0.69	0.153
S19	Number of frequently contacted emotionally close relatives	1.05	0.741
	Interaction: A level or higher education * Number of frequently contacted emotionally close relatives	1.51*	0.077
	Combined A level or higher education	0.97	0.869
S20	**Childcare provided by a relative**	1.57 **	0.039
	Interaction: University degree or equivalent * Childcare provided by a relative	1.10	0.832
	Education level: University degree or equivalent	1.69 **	0.039
	Education level: A level or equivalent	0.86	0.461
S21	Childcare provided by a relative	1.68 **	0.021
	Interaction: University degree or equivalent * Childcare provided by a relative	0.83	0.657
	Education level: University degree or equivalent	1.73 **	0.014
	Education level: A level or equivalent	0.91	0.691
S22	Childcare provided by a relative	1.66 *	0.051
	Interaction: A level or higher education * Childcare provided by a relative	0.86	0.688
	Combined A level or higher education	1.20	0.365

A full set of control variables are included in the above models though they are not displayed

1.7 Nested 'best fitting' models

In the paper I present 'full' models showing all the potentially relevant variables. This is common practice in Behavioural Ecology and evolutionary research, and so appropriate given the target journal for this paper. In social science it is often the case that researchers will present the results for a nested 'best fitting' version of the model with only significant variables. The below models were generated through manual backwards stepwise selection (Agresti and Finlay 1997) with the removal of variables that were non-significant on the basis of the weakest p value (except for the key explanatory variables or those required by the method i.e. the time controls). I considered the models produced by all three explanatory variables simultaneously in the model selection process as I wanted the models to remain comparable. I maintained variables at each step if they were significant at the 10% level in any one model even if they were outside this level of significance in a different model. In total 57 models were fitted over 19 steps.

Both the models presented in the paper and those found through stepwise selection are very similar, in terms of both effect size and p-value significance. There is also limited evidence from likelihood ratio tests or by looking at the reduction in the R-square that the best fitting and full models are substantially different. In short, the conclusions of the paper would not by altered by looking at a nested best fitting version of the model rather than the full model.

Table 7: Best fitting model

	S23		S24		S25	
	RR	P	RR	p	RR	p
Number of emotional close relatives	1.144	0.199				
Number of frequently contacted emotional close relatives			1.257**	0.045		
Childcare provided by a relative (ref: Does not use childcare)					1.530**	0.029
Formal childcare used (ref: Does not use childcare)					1.496*	0.049
Other form of childcare use (ref: Does not use childcare)					0.728	0.129
Time employed included overtime (hours)	0.996	0.385	0.996	0.372	0.989*	0.069
Education level: University degree or equivalent	1.843***	0.002	1.893***	0.001	1.846***	0.003
Respondents who have ever attended religious organisations	1.431*	0.07	1.440*	0.065	1.446*	0.064
Household contains						
A partner	2.229***	0	2.308***	0	2.455***	0
Time since 1st birth (months)	0.983***	0	0.983***	0	0.983***	0
Age (years)	1.745***	0	1.731***	0	1.741***	0
Age (years squared)	0.990***	0	0.990***	0	0.990***	0
Wave (reference Wave 6 2002-03)						
Wave 1	1.109	0.71	1.135	0.648	1.116	0.697
Wave 2	0.929	0.796	0.937	0.819	0.960	0.887
Wave 3	0.884	0.668	0.878	0.651	0.897	0.706
Wave 4	1.177	0.578	1.185	0.562	1.195	0.545
Wave 5	1.097	0.749	1.077	0.798	1.081	0.79
Likelihood ratio test compared to model included in paper	LR chi2(14) = 7.83 P = 0.8979		LR chi2(13) = 7.79 P = 0.8569		LR chi2(13) = 8.38 P = 0.8177	
Pseudo R squared for above model	0.1265		0.1285		0.1348	
Pseudo R squared full model (as presented in the paper)	0.1332		0.1351		0.1419	
Loss of Pseudo R squared in reduced model	0.0067		0.0066		0.0071	

1.8 Main effects of explanatory variables in the reduced (minus Wave F) dataset

The models presented in Table Seven on geographic proximity and specific relatives are not completely comparable to the results of the multivariate regressions presented Tables Four and Five as Wave F is removed and thus the number of spells is reduced by one sixth from 1115 to 917.

The results of the main effects for the three explanatory variables used elsewhere in the reduced dataset are set out in Table 8 below. The effects are very similar to those in Table Three of the paper. I include this information here to confirm that the information from Wave F was not substantially different to the other waves of the survey, and thus the conclusions drawn on associations seen for the geographic proximity and specific relatives variables (as set out in Table Seven in the paper) cannot be dismissed solely due to the removal of Wave F altering the dataset.

Table 8: Effect of explanatory variables on the risk of a second birth in the reduced dataset without Wave F

	RR	p value
Number of emotionally close relatives Model (S26)	1.25	0.66
Number of frequently contacted emotionally close relatives (S27)	1.34**	0.024
Childcare provided by a relative (S28)	1.59**	0.033

A full set of control variables are included in the above models though they are not displayed

2 Additional analysis conducted but not mentioned in paper

2.1 Other variables considered

2.1.1 Migration

I had originally wanted to make the models for the first and second births papers as similar as possible. Another aspect which could influence whether kin provide childcare is whether or not the geographic distance between relatives recently changed. There is information on whether the respondent household is located in a different region (broadly similar to the Government Office Regions) to the previous wave. I was able to include this information in the first birth paper however there were only 22 occasions (less than 2% of spells) in the second birth data, which is insufficient for meaningful analysis of this variable. I therefore cannot include this variable in the second birth model.

2.1.2 Sex biased investment

Trivers and Willard (1973) theorised that humans and many other species undertake conditional sex-biased investment in offspring to produce the most beneficial sex of offspring for the conditions in which the parents find themselves. This is due to differences in males' and females' innate biological capacity to have offspring. For most mammalian species, including humans, the capacity of a high status male in good conditions to have offspring is primarily limited by his access to mates. The 'fixed costs' of impregnation (sperm) are negligible. Females have much higher 'fixed cost' investments through prolonged gestation and lactation. On the basis of this there will be more variance in male reproductive success compared to female reproductive success, as some males may have potentially hundreds of offspring whilst some males will have none (Bateman 1948). Trivers and Willard therefore hypothesised that high-status good-condition parents should invest more in male offspring to 'maximise' their reproductive success in the next generation. On the other hand low-status poor-condition parents should invest relatively more in female offspring to 'risk minimise' their changes of lineage extension. Whilst sex-biased investment from human parents seems to occur in traditional societies its effect in contemporary populations is still debated (Koziel and Ulijaszek 2001; Keller, Nesse et al. 2001). Most of the literature has focused on bias in parental investment but the same logic would also influence other relatives' investment strategies. In effect kin should invest more when the respondent has the 'right' sex offspring for their conditions. So relatives should invest in their relatives' male children in good conditions and their relatives' female offspring in poor conditions. This in turn could influence fertility. Unfortunately the dataset was insufficient to support three way interactions between offspring sex * parental conditions * relative provision of childcare. For example there were only 29 occasions when a tertiary educated (a marker for good condition) respondent had a female offspring and was receiving relative-provided childcare. This would be another interesting area to explore in future research.

2.2 Attrition analysis

I checked to see if attrition between the interview and the end of the measurement period for a second birth could have altered the results. It is possible that kin influence indicators could have been associated with lowering attrition rates as BHPS administrators may have found it easier tracing adults with stronger kin contacts. To

check post-interview attrition I removed individuals who had their last interview within 27 months of the reporting of their kin influence indicators. This resulted in the removal of 69 spells reducing the total data set to 1046 spells. However it had negligible effect upon the explanatory variables, the results are set out in Table 9 below. I am including this information here to confirm that post-interview attrition is not a major factor in explaining the results.

Table 9: Attrition analysis

Model	Variable	Without controlling for attrition		With the removal of all spells with a possible risk of a non-reported birth	
		RR	*P*	RR	*P*
S29	Number of family in friendship group	1.4	*0.233*	1.14	*0.255*
S30	Number of family seen 'most days' in friendship group	1.26**	*0.045*	1.27**	*0.046*
S31	Childcare provided by a relative	1.60**	*0.02*	1.61**	*0.019*

A full set of control variables are included in the above models though they are not displayed

2.3 Effect of the kin orientation of a social network prior to first birth

I was interested in the long term impact of emotionally close relatives by examining if their presence *before* the respondent's first birth influenced her transition to a second birth. As set out in the discussion kin priming from earlier in a respondents life could be responsible for developing social norms conducive to higher fertility. The extent to which the number of emotionally close relatives remains stable over time is raised at the start of discussion and in section 1.2 of the supplementary material. The final column of Table 1 in the paper (page 111) shows substantial volatility for respondents who provided more than one wave of information after their first child is born.

I merged the second birth dataset with that from the first paper which gave me information on the number of emotionally close relatives a respondent reported prior to her pregnancy with her first child. Unfortunately only 44.6% of spells in the second birth dataset could be matched with a measure of the emotionally close relatives whilst the respondent was childless, as in many cases she had not been interviewed by the BHPS during this period of her life. For those respondents who could be matched

several had numerous waves of information on emotionally close relatives, so I took the mean number of emotionally close relatives that the respondent reported prior to her first birth. Due to the very large volume of missing data only very tentative conclusions can be drawn from this analysis and so it was excluded from the paper. Nevertheless it appears that having emotionally close relatives *prior to the first birth* also increases the risk of a second birth.

There is a positive bivariate association between the proportion of spells ending in the second birth and the extent of kin interaction prior to the first birth. Overall 21.7% of spells ended in a second birth and all the measures of the presence of emotionally close kin before a respondent's first child show are associated with a higher probability of the spell being followed by a second birth (as measured by chi-square tests – not shown)

Table 10: Bivariate relationship between indicators of kin influence prior to the first birth and subsequent second birth risk

	N	% of spells	% end in 2nd birth
Missing emotional close relatives information prior to first birth	618	55	17.15
No emotionally close relatives reported prior to first birth	192	17	24.48
Average *less than one* emotional close relative in the spells prior to first birth	226	20	29.65
Average *more than one* emotional close relative in the spells prior to first birth	79	7	27.85
An emotional close relative (above two categories combined) prior to first birth	305	27	29.18
No frequently contacted emotional close relatives prior to first birth	341	30	23.75
A frequently contacted emotional close relatives prior to first birth	156	14	35.26

There are only a limited number of second birth spells where the respondent provides information on an emotionally close relative in both periods. But where this occurs there is a higher than average propensity for that the spell to be followed by a second birth.

Table 11: Respondents reporting emotionally close relatives before and after their first birth – bivariate association

	N	% of spells	% end in 2nd birth
An emotionally close relative in both periods	243	21.79	29.63
A *frequently contacted* emotionally close relative in both periods	90	8.07	40.00

I also included the indicators of kin influence before the first birth in full multivariate models, and this shows a similar relationship (see Table 12). Having a frequently contacted emotionally close relative prior to the first birth significantly increase the risk of second birth, and this is also marginally the case even when controlling for the presence of emotional close relatives in the proximate environment (Model S36). However there does not appear to be a significant multiplier effect as seen in the interactions models (S37 and S38) whereby having a relative in both environments does not generate a significant effect.

I also ran the above models again, this time only including those who have a pre-first birth indicator of emotionally close relatives (i.e. dropping all those without first birth information). This decreases the number of spells to just 497. In this subset having a frequently contacted emotionally close relative prior to the first birth remains significant. Again interactions between the pre and post first birth measures did not show a significant multiplying effect (results not shown).

Table 12: Respondents reporting emotionally close relatives before and after their first birth – multivariate results

Model	Explanatory variables: *Reference No Relatives in FG prior to first birth*	RR	p
S32	Missing a relative measure prior to first birth	1.14	0.580
	Average <1 emotionally close relative prior to first birth	1.21	0.433
	Average >1 emotionally close relative prior to first birth	1.25	0.494
S33	Missing a relative measure prior to first birth	1.14	0.580
	A emotionally close relative prior to first birth	1.22	0.385
S34	Missing a relative measure prior to first birth	1.18	0.421
	A frequently contacted emotionally close relative prior to first birth	1.66**	0.027
Including both variable from prior to first birth and after first birth			
S35	Missing a relative measure prior to first birth	1.13	0.605
	A emotionally close relative *prior* to first birth	1.18	0.471
	A emotionally close relative *after* to first birth	1.09	0.637
S36	Missing a relative measure prior to first birth	1.17	0.455
	A frequent contacted emotionally close relative *prior* to first birth	1.55*	0.064
	A frequent contacted emotionally close relative *after* to first birth	1.24	0.207
Interaction			
S37	Missing a relative measure prior to first birth	1.13	0.614
	Interaction: A emotionally close relative *prior* to first birth AND a emotionally close relative *after* to first birth	0.75	0.468
	A emotionally close relative *prior* to first birth	1.46	0.306
	A emotionally close relative *after* to first birth	1.16	0.448
S38	Missing a relative measure prior to first birth	1.17	0.456
	Interaction: A frequently contacted emotionally close relative *prior* to first birth AND a frequently contacted emotionally close relative *after* to first birth	1.03	0.945
	A frequent contacted emotionally close relative *prior* to first birth	1.53	0.207
	A frequent contacted emotionally close relative *after* to first birth	1.23	0.271

n=1115 and a full set of control variables are included in the above models though they are not displayed

2.4 Third birth transition

I attempted to analyse the influence of kin on third birth transition in the BHPS using the same methods as employed in the previous two papers. There were a sufficient number of spells for analysis (1,618) but there were only 111 valid births captured in the 9-27 month period after the interview. This meant that there were an insufficient

number of third births to allow separate analysis of the kin influence indicators on this transition. For example there were only 37 spells where a third birth occurred after the respondent had reported frequent contact with an emotionally close relative. The small number of third births is in keeping with the national picture; less than a quarters of births in the UK are third or higher parity (ONS 2009).

The transition from childlessness to parenthood is clearly qualitatively different to latter parity progressions, but a possible approach is to combine analysis for later births together. This is can be sometimes be considered beneficial. For example Kravdal (2001) used Norwegian register data to estimate a separate and a joint model for second and third birth intervals. In both the separate models higher education seemed to lead to shorter birth intervals. However when a joint model was run education led to longer birth intervals. The joint model takes into account selection effects whereby educated females typically have children at older ages and so may better account for characteristics within the females of the different education strata.

However, it can also be risky to assume that the fertility decision processes is the same for second births and third births (Evans, Barbato et al. 2009). There are unique factors that influence the progression to thirds births, a notable example being the sex composition of previous births. This is an important area of theoretical consideration in the evolutionary biology (See Section 2.1.2, page 130). There is also empirical evidence that parents in most developed countries display a desire for ‘one of each’ with substantially higher rates of third birth occurring when the two preceding children are of the same sex (Hank and Kohler 2000; Pollard and Morgan 2002; Kippen, Gray et al. 2005). There is a substantial increase in the complexity of a joint model as the shared characteristics of the individuals providing both second and birth information means that it is necessary to use multilevel techniques. Moreover with third births models there is a substantial risk of a *‘long-term survivors’* problem. (Steele 2005). Event history analysis models can produce biased results when a substantial proportion of spells that are indicated as ‘right censored’ are in fact respondents who will never undergo the event. I therefore decided to limit analysis to just the transition to second birth.

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PAPER THREE

Context Effects and Fertility Preferences: the Influence of Preceding Questions on the Reporting of Attitudes towards Fertility

Abstract

In surveys, preceding questions can influence respondents' answers to later questions. As an individual's opinions toward their own fertility are highly dependent upon their circumstances, prior questions might influence the reporting of fertility preferences. We tested this using an internet experiment of 2277 childless British university students. We asked participants questions on their fertility preferences without any prior questions or after a set of questions on adult mortality, childhood mortality or dental health. We found that participants' reporting of their fertility preferences seemed to be influenced by all three sets of preceding questions. We conclude that information on attitudes towards fertility collected through surveys needs careful interpretation which takes into account their context within a questionnaire.

Introduction

'People have fewer children than they really want – and we know *that there is this mismatch between desire and reality because surveys consistently tell us that this is so'* (Howse 2007, page 5, emphasis in the original)

'Surveys have revealed the gap which exists between the number of children Europeans would like and the number that they actually have. This means that, if appropriate mechanisms existed to allow couples to have the number of children they want, the fertility rate could rise…' European Commission Green Paper 'Confronting Demographic Change: A New Solidarity between the Generations' (2005)

Demographers and social scientists have long been interested in fertility preferences. For equally as long there has been scepticism about their accuracy (Westoff, Mishler et al. 1957). This is because such attitudes do not wholly predict fertility and are often

revised as individuals' age and their circumstances change. The aim of this paper is to reiterate the need for careful interpretation of fertility preference measures collected as part of multi-purpose social surveys. Here we demonstrate a new reason for caution: simply changing when fertility preference questions are asked in a questionnaire can significantly affect the responses.

There are reasons to be concerned about fertility preference measures but this does not justify ignoring them. They are vital for understanding fertility processes and, as we will argue, for informing governments' family policies. However, more attention is required to improve their measurement and interpretation. Our key recommendation is simply to consider responses to such questions in the light of surrounding questions. Second, given the increasing prevalence of CATI and CAPI (Computer Aided Telephone and Personal Interviewing) it is becoming easier to randomise question ordering. We recommend this should be undertaken more frequently to test the reliability of these items and to control for question order effects.

In this paper we will start by reviewing the literature on fertility preferences, their potential uses and the problems noted so far in their measurement. We will then go on to discuss preceding question context effects, and we will set out why we think that fertility preferences might be at particular risk of suffering context effects. We will then illustrate our point using an online experiment that manipulated question ordering. In this experiment participants answered questions on their fertility preferences without any prior questions or after a random battery of questions on either adult mortality, childhood mortality or their dental health. We found that question ordering mattered: fertility preferences differed according to which (if any) preceding questions were asked.

Fertility preferences

We will use the term fertility preferences in a very broad sense, including within it numerous conceptual dimensions and methodological operationalisations. These include how many children would a respondent like or expect to have, when they would like to have them and also more indirect Value of Children measures (Hoffman and Hoffman 1973; Nauck and Klaus 2007) on the perceived costs and benefits of

children. For the sake of consistency we will use the term fertility preferences as a catch-all term throughout the paper, though it would be possible to use others, such as 'fertility attitudes', 'fertility opinions', 'reproductive preferences' etc.

The earliest fertility preference survey item that we have found was from a 1936 US Gallup survey which asked respondents *'what do you think is the ideal number of children for a family to have?'* (Mindick 1977) and questions on fertility preferences continue to be asked in many large, representative and multipurpose surveys. In the UK, for example, fertility preference questions have been asked in the General Household Survey (GHS), the British Household Panel Study (BHPS), the National Child Development Study (NCDS), the British Cohort Study (BCS), and the Millennium Cohort Study (MCS). Notable international examples include the European Social Survey (ESS), the Eurobarometer, the American National Longitudinal Surveys (NLS), the Household, Income and Labour Dynamics in Australia survey (HILDA) and the Demographic and Health Survey (DHS) series.

Why are fertility preferences important?

Writing in 1977 Oskamp argued that an individual's ideal number of children was one of the most important attitudes for social scientists to measure, placing it alongside political opinion polling and assessments of social prejudice (racism, sexism etc). Fertility preferences remain important for demographers. At the recent European Population Conference in Vienna 2010 there were 68 papers included in the fertility stream; of these 22 (32%) included fertility preferences either to explain actualised fertility or as a concept in their own right. There are two main reasons why demographers are (or should be) interested in the accurate measurement of fertility preferences.

First, it is necessary for our understanding of fertility processes. Many fertility theories assume that changes in fertility preferences drive changes in actual fertility; notable examples include Becker (1960), Caldwell (1976) and Turke (1989). It is well noted that attitudes influence, though do not wholly determine, many behaviours (Ajzen 1991). Fertility preferences have been shown to be significant predictors of future reproduction at both the aggregate (Westoff 1990; Pritchett 1994) and

individual level (Freedman, Hermalin et al. 1975; Schoen, Astone et al. 1999; Berrington 2004; Testa and Toulemon 2006; Gipson and Hindin 2009; Nettle, Coall et al. 2010). More abstract Value of Children measures have also been shown to correlate with parity progressions (Nauck 2007).

Because they predict behaviour, fertility preferences can be used in fertility forecasting. Attempts to incorporate fertility desires and expectations into demographic projections goes back many years (Whelpton and Freedman 1956) and as fertility assumptions in population projections are regularly inaccurate (Shaw 2007) (Jefferies 2008), perhaps more attention could be paid to changing fertility preferences. Fertility intentions have not been formally included within official population projection models for the UK; however fertility intentions as reported in the General Household Survey are considered by officials at the Office of National Statistics as part of the evidence base for the fertility assumptions used in the national population projections (Jefferies 2008).

Recent speculations on the future of fertility in Europe have placed great importance on fertility preferences (Bongaarts 2001; Bongaarts 2002; Goldstein, Lutz et al. 2003; Morgan 2003). A good example is the influential 'low fertility trap' hypothesis (Lutz, Skirbekk et al. 2005; Lutz 2007). A key point of this hypothesis is the circular relationship between actualised fertility and fertility preferences; as fewer individuals have children, national fertility preferences decline, which in turn leads to further reductions in actualised fertility.

However, it has also long been noted that fertility preferences' predictive validity at an individual level is not particularly strong (Westoff 1957; Westoff and Ryder 1977), and that different fertility preference measures vary in their ability to accurately predict behaviour (Miller and Pasta 1995; Gipson and Hindin 2009; Ni Bhrolchain, Beaujouan et al. 2010). Moreover their 'accuracy' is also sometimes dependent on the characteristics of the individual being surveyed and the characteristics that influence fertility preferences' accuracy differ between communities (Noack and Østby 2002; Van Peer 2002; Quesnel-Vallée and Morgan 2003; Morgan and Heather 2010).

A second, and perhaps undervalued, reason why fertility preferences should be of interest to the research community is that they form a critical component in the construction of fertility policies. The most widely known of these is the 'unmet need' argument for the provision of contraceptives in high fertility societies where there is a 'gap' between respondents' reported birth control practices and their fertility preferences (Bongaarts 1991) (arguments on the validity of 'unmet need' have been set out elsewhere (Dixon-Mueller and Germain 1992; Casterline and Sinding 2000)). This issue is not confined to high fertility societies. Increasing the proportion of 'intended' pregnancies is also an explicit policy of the U.S. Department of Health and Human Services[13].

Recently 'unmet need' arguments have also been turned upside down and are being used to support pro-natal, family friendly policies in contemporary low fertility countries. Here the 'unmet need' is for children rather than contraception (Liefbroer 2009). Fertility preference data collected from European women, for example, typically finds women desire more than two children on average, whereas TFRs for almost all European countries are below two (Bongaarts 2002; Goldstein, Lutz et al. 2003; Morgan 2003).

Such arguments depend on fertility preference data being a true reflection of what individuals actually desire, as the stated rationale for such policies is to allow individuals to achieve their reproductive goals. Here, for example, is what one author considers should be the context for the implementation of fertility policies in liberal democracies:

> *"A government that sets targets for fertility is trying to change behaviour… from the point of view of liberal democracies what is unacceptable is a rationale for intervention which rests on a collective goal other than the provision of an institutional context for individual flourishing"* (Howse 2007, page 4)

[13]see the National Health Promotion and Disease Prevention Objectives http://www.healthypeople.gov/hp2020/default.asp

Howse's argument emphasises the role of institutions as facilitators, allowing the individual citizen to achieve what they desire. Therefore if citizens fail to achieve the number of children that they desire, and blame is attributable to institutional failures, this requires policy redress. Several academics have used this reasoning in promoting pro-natal policies in low fertility societies (Chesnais 1998; Morgan 2003; McDonald 2006; Philipov 2009).

European states across welfare traditions, such as Germany and the UK, have recently increased public expenditure and implemented policies with pro-natal or pro-family objectives in mind (Lewis, Knijn et al. 2008; Henninger, Wimbauer et al. 2008; Jensen 2009; Fleckenstein 2010). There have been many justifications for the policies that directly or indirectly may influence fertility. But the quotation below from a prominent British Conservative politician is a good example of how data on fertility preferences have been used to justify such policies:

> "*In terms of public policy, it is important to look at the reasons behind (the) fall in the fertility rate. If it is simply a choice, if people are having as many children as they like, then we have no right to intervene. However, <u>if people would like to have more children</u>, but don't because of socio-economic factors, then we should step in to help…*" David Willets MP (2007, our emphasis)

Similar sentiments have been echoed in policy documents from other national and supranational European actors (Philipov, Thévenon et al. 2009; Fox 2009). It is precisely because individuals' fertility preferences do not equate to their actualised fertility that some politicians see room for policy manoeuvre. Whilst it is possible to justify pro-natal policies on grounds other than fulfilment of individual fertility preferences, for example maintaining a nation's labour force or tax base (Demeny 1986; McDonald and Kippen 2001), such justifications requires a substantially different (and less liberal) ideological basis for state intervention.

Accurate measurement of fertility preferences is therefore required both for informing family policy and in order to understand and predict fertility processes.

Why are fertility preference measures problematic?

Unfortunately there are severe inherent difficulties for the successful measurement and interpretation of fertility preferences. Demographers traditionally have worked on two events, birth and death. Both of these events can be relatively easily conceptualised, recorded / recalled, and quantified (Morgan and Hagewen 2005). Attitudinal measures, including fertility preferences, fundamentally do not share these qualities. They are less conceptually and methodologically straightforward. A significant problem measuring and analysing fertility preferences is that they encompass numerous dimensions.

The first distinction, and probably the most important, is between expectations and ideals: the number of children an individual expects to have may not be the same as the number of children that individual would ideally like to have, given no constraints. Morgan and Hagewen (2005) argue that a great deal of analysis has failed to adequately differentiate between desired and expected fertility. Childbearing can occur with any combination of aspiration and anticipation and an individual's capacity to control reproduction is limited by both social and biological factors. So a birth or a pregnancy can be 'unwanted' but still 'likely', or can be 'desired' but 'a surprise' (Santelli, Rochat et al. 2003). A second division is between the total number of children expected/desired and parity specific measures, i.e. questions that ask whether respondents want or expect 'a(nother) child.' A third distinct dimension is between the above measures and attitudes towards the timing of children, so a birth could be 'mistimed' rather than wholly 'unwanted' (Trussell, Vaughan et al. 1999). Fourth, some surveys include more indirect questions on the Value of Children (VOC (Hoffman and Hoffman 1973; Nauck and Klaus 2007); primarily questions on the costs and benefits of having children. We include these under the label of fertility preferences as such indirect measures of the value of childbearing fit into prominent theories on the relationship between attitudes and intentions e.g. Ajzen (1991). These cost and benefit measures will vary in their relationship with the more direct fertility preferences items, and with actualised fertility (Nauck 2007). Finally, fertility preference questions may ask how many children a respondent believes other females within her community should have, not necessarily the number of children she herself desires. A cross-national European survey, the Eurobarometer, asked respondents 'In

your country today, what do you think is the ideal number of children for a family?' (Goldstein, Lutz et al. 2003). It is also worth noting that all these items can be measured prospectively or retrospectively, methods of data collection which may produce different results.

Many researchers have identified the treacherous nature of the terrain encompassed by these attitudes. In this paper we cite 35 papers that consider fertility preferences; 25 of these articles post warnings of conceptual ambiguities. Either the researcher or respondent could be unclear about the specific dimension under consideration, and fertility preference measures risk lacking coherent 'construct validity' (Shadish, Cook et al. 2001). Whilst data on all dimensions of fertility preferences are frequently collected, rarely are all the dimensions measured in the same survey, which in turn limits cross-survey comparison.

However, our main concern is that most measures fail to fully take into account the uncertainty and context dependent nature of fertility decision making. It has long been noted in opinion polling methodology that capturing the level of certainty / intensity with which the opinion is held is vitally important (Likert 1932; Katz 1944). Likert questions allow many attitudinal measures to capture both direction and intensity in a single item as respondents vary the extent of their agreement or disagreement to a statement, i.e. respondents may '(dis)agree' or 'strongly (dis)agree.' The more indirect Value of Children measures can use Likert type items to capture both direction and certainty. However, this approach is not readily applicable for many fertility preference questions. In particular the questions on total number of children such as 'how many children would you like to have?' require a second follow up item to measure uncertainty, such as 'how certain are you that you will have this number of children?' This is rarely undertaken due to the time and space constraints of large general social surveys.

This is represents a problem, since evidence suggests that individuals are frequently uncertain about their fertility preferences. Ni Bhrolchain, Beaujouan et al. (2010) show that when asked about their expected age at childbearing respondents displayed a clear digit preference whereby they disproportionally choose ages ending in either 0 or 5. This is considered to be 'compelling evidence of substantial uncertainty' by Ni

Bhrolchain, Beaujouan et al. (2010, page 26). Qualitative work by Bernardi, Mynarska et al. (2010) has shown that the respondents who report ‘don’t know’ as an answer category vary a great deal in what this response means to them. To compound these problems, May (2008) has highlighted that interviewers dealing with uncertain respondents can be extremely arbitrary when probing and coding their answers. Zabin (1999) has argued that a failure to adequately control for uncertainty has been major weakness in the analysis of fertility preferences measures.

This uncertainty can also be seen in repeated measurements of the same individual’s fertility preferences, which often show substantial volatility over time (Heiland, Prskawetz et al. 2008; Reimondos and Gray 2009; Iacovou and Tavares 2011). A well noted change is that ideal and expected fertility declines as age increases (Smallwood and Jefferies 2003; Berrington 2004; Kodzi, Casterline et al. 2010; Ni Bhrolchain, Beaujouan et al. 2010). Age will directly influence some ‘expected’ fertility as fecundity declines. Age related fecundity could also influence ‘desired’ fertility as those who have had fewer children than they initially desired justify their decision post-hoc i.e. seek to reduce their cognitive dissonance (Festinger 1962). However, fertility preferences can also be subject to sudden upward revisions which surprise even the individual themselves (Rotkirch 2007). It may not be age itself but other contextual factors that cause an individual’s fertility preferences to change over time. The literature regularly mentions three outside factors that influence an individual’s fertility preferences; we will discuss each in turn.

First, partnership context affects fertility preferences. Most people will desire to raise children in a partnership and failure to secure such a relationship could lower fertility intentions or preferences. One of the values attributed to children is the strengthening of partnership bonds (Nauck and Klaus 2007), and partnership formation seems to heighten desires and expectations towards childbearing (Reimondos and Gray 2009). Not only does partnership matter but so will the fertility preferences of each partner. Demographic research has traditionally, and probably mistakenly, given relatively limited attention to male fertility and fertility preferences (Greene and Biddlecom 2000). Actualised fertility will be the product of some form of negotiation between males and females (and perhaps other members of the extended family). Couple-level fertility preferences are not simply a mid-point between the two partners’ preferences

(Berrington 2004; Casterline and El-Zeini 2007). Partners are likely to resolve differences to ensure partnership stability, and some will prioritise their partnership over their desire to have (or not have) children. The resolution of partnership differences will also occur very differently across socio-cultural contexts (Voas 2003). As a further complication the two partners may have inaccurate perceptions of the other's fertility preferences (Miller, Severy et al. 2004). Fertility preferences may also be influenced by gender inequality (Puur et al 2008; Schober 2009), as preferences will be affected by expectations of a partner's contribution to childcare and domestic work. Lehrer and Kawasaki (1985) demonstrated, for example, that the allocation of childcare influences future fertility intentions

Secondly, actually having children also changes fertility preferences (Berrington 2004; Reimondos and Gray 2009; Iacovou and Tavares 2011). This is relatively unsurprising as parenthood often dramatically alters an individual's lifestyle. The process of parenthood also leads to substantial physiological and psychological changes, particularly, but not exclusively, for females (Petch and Halford 2008). Parenthood will alter fertility preferences as the actual costs and benefits of children become clear. Each additional child may change the costs and benefits of parenthood still further, so that Gipson and Hindin (2009) criticise the use of 'total number of children' items on grounds that individuals are only really able to consider their *next* child. Whilst demographers may find single questions about an individual's ideal total family size convenient, decision-making 'on the ground' is more likely to follow a parity-specific 'moving target' (Morgan and Hagewen 2005).

In societies which delay childbearing, childless individuals are also likely to come into increasing contact with parents as they age, and so will become better informed of the nature of childbearing from their peers' experiences. Though this effect may be partially mitigated as social networks alter to maintain homophily of childbearing (Keim 2009). Whilst some fertility preferences in general decline with age, contact with other individuals' young infants may work in the opposite direction, stimulating maternal and paternal instincts. Infants have been described by Hrdy (2009) as 'sensory traps' for adults due to their *kindchenschema* features such as large low lying eyes, large heads and pudgy cheeks.

Finally, in contemporary resource rich societies, there are substantial 'competing preferences' (Bongaarts 2001). When asked, a respondent may honestly state that she desires to have children, but if exciting career or lifestyle opportunities become available she could decide against it. The extent to which these activities are truly 'competing' will also be influenced by the availability of childcare (formal or informal). The inverse is of course also possible, finding a career or lifestyle unrewarding may mean that individuals decide to invest their time and energy in children. Qualitative research shows that dissatisfaction with current career or lifestyle prospects can be an important factor in explaining early motherhood (Arai 2003). Aarsen and Altman (2006) explicitly argue that fertility levels can be explained by the competition between cultural production and genetic reproduction. The key point is that individuals do not fully know what career, leisure or childcare opportunities will be available in the future.

This list of contextual factors is far from exhaustive and its purpose is primarily to illustrate the difficulties of obtaining a 'correct' measurement of fertility preferences. It is difficult for respondents to predict their future circumstances for each of the above factors, which will in turn accumulate their uncertainty when considering their options for childbearing.

Many non-human species adjust their fertility to fit their ecological conditions (Stearns 1992). Our species may have evolved to be particularly sensitive to socio-ecological context when making reproductive decisions. In comparison to other primates successful childbearing is particularly difficult and risky for humans, from the birth process itself (Trevathan 1987) to the prolonged and intense dependence of offspring (Bjorklund 2007; Bogin 2009). Throughout our evolutionary history having too many or too few children, or having them at the 'wrong' time could dramatically escalate the risk of child and maternal mortality or even lineage extinction. Today in resource rich, low fertility environments having children still represents a substantial risk, due to the huge investment of resources (both of finances and time) required by parents to deliver socially competitive offspring. Trade-offs between the quantity and quality of children are still seen even in contemporary societies (Grawe 2003; Lawson and Mace 2010). It is adaptive for human reproductive strategy to be plastic, and able to respond to the conditions in which individuals find themselves. Though it is

important to stress that any response will be due to *perceived* changes in childbearing conditions, and perceptions can be inaccurate.

The primary aim of this paper is to highlight the possibilities of internal question ordering 'context effects' within social survey questionnaires. It is because fertility preferences are so dependent on the external conditions of an individual's life that we suspect that priming individuals to think about particular topics will alter their responses to fertility preference questions.

Context effects

Survey methodologists define context effects as the impact of earlier items on later responses (Tourangeau, Singer et al. 2003) (they are also referred to as 'question-order effects' (Rimal and Real 2005)). Context effects have been found in many areas and have been shown to significantly influence the reporting of subjects as diverse as visual impairments (Todorov 2000), life satisfaction (Schwarz, Strack et al. 1991) and the approval of census data collection (Tourangeau, Singer et al. 2003). Related 'contextual effects' studies have shown that physiological manipulations also influence participants' reporting, notable examples include the stimulation of head nodding (Wells and Petty 1980; Gail, Ramil et al. 2006) and the zygomaticus (smiling) muscles (Strack, Martin et al. 1988).

Context effects of preceding questions can be generated from both the immediately preceding questions or from items much earlier in the survey. There are numerous ways previous items could cast an influence on following questions. Tourangeau and Rasinski (1988) discuss eight mechanisms that generate context effects. Here we will focus on one of these eight mechanisms: priming. This is an effect of previous items on the respondent's salient thoughts. During the process of answering an attitudinal item respondents generally have a very short amount of time to produce an opinion, often on a highly complex issue. Formulating such an attitude requires a respondent to almost instantaneously retrieve from their memory relevant information, potentially over a whole range of topics. Previous items may result in certain information being retrieved more readily than other information. Tourangeau and Rasinski (1988) set out a nice analogy of priming with sampling: just as only sampling from one subgroup in

the population will clearly bias results, so too particular salient thoughts will bias the 'sampling frame' of accessible information that is retrieved by the respondent.

There is debate within the literature on the frequency with which context effects actually occur within surveys. Research by Schuman and Presser (1981) and Smith (1991) suggested that they are relatively infrequent. Other research has shown that they are not always replicated (Bishop, Oldendick et al. 1985). Tourangeau, Rips et al. (2000) argue that they remain a risk, but should be evaluated on the basis of the conceptual relationship between the contextual and affected items.

Because fertility preferences are related to so many contextual factors there are numerous potential priming effects that could influence them. For example, preceding questions could (unintentionally) prime a respondent towards thoughts of children being potentially detrimental to her career, the physically painful nature of childbirth or, more positively, towards thoughts of old age support and companionship. This is not merely a theoretical risk. For instance the BHPS regularly asks respondents under the age of 21 a battery of questions rating the likelihood of particular events occurring in their lives[14]. Two events are of particular interest. The fifth event listed is "*Be kept back in your job due to family reasons, e.g. raising children?*" which is clearly priming salient thoughts of the difficulties which children may bring to a career. Five items later the respondents are then asked to rate how likely they are to *"Have a child."* To give another example, the first wave of the MCS asks the infant's mother a battery of questions on the delivery of the cohort child, such as *"How long did the labour last?"* and *"Which, if any, of the following types of pain relief did you have at any time during labour?"* before asking *"Do you plan to have any more children?"* [15] Again, this is priming women towards an unpleasant (to put it mildly) aspect of having children. With both the BHPS and MCS it is impossible to know what the responses would be without the priming effect of the earlier items.

[14] The exact wording being *"Please look at this card and tell me on a scale from 0% to 100% how likely it is that the following events will happen in your life in the future. How likely is it that you will* [given event]. For full information on the BHPS see http://www.iser.essex.ac.uk/survey/bhps

[15] For full information on the Millennium Cohort Study see www.cls.ioe.ac.uk/mcs

Fertility preferences and mortality perceptions: an illustrative example

Here, we describe an experiment that looks for preceding question context effects upon the reporting of fertility preferences. We used an internet experiment to test for an effect of mortality salience on fertility preferences by priming some respondents to think about mortality before asking them a battery of questions on fertility preferences. The association between mortality and fertility is one of the oldest and most discussed relationships in demography, though a relationship between mortality priming and fertility preferences is less intuitive. Why should thinking of mortality bias the retrieval of information relevant for reproductive decisions?

In the demographic literature, a positive correlation between mortality and fertility is commonly observed. The influence of mortality on fertility decisions has generally been considered to be the result of conscious replacement effects (whereby parents replace deceased offspring) or insurance effects (whereby they have additional offspring in mitigation of expected future mortality (Preston 1978; Montgomery 2000)). There is, however, mixed evidence from qualitative research on the extent to which there is a conscious, or at least articulated, link. Researchers have found that perceived mortality and morbidity are expressed as reasons for early childbearing in socio-economically deprived areas of low fertility countries e.g. Geronimus (1996), but are not mentioned with regards to fertility decisions in high fertility settings (Randall and LeGrand 2003; LeGrand, Koppenhaver et al. 2003). Our expectation for a link is based on life history theory, derived from evolutionary theory. We have argued previously that there is likely to be a psychological, though *not necessarily conscious*, relationship between mortality perceptions and fertility preferences (Mathews and Sear 2008).

One of the predictions of life history is that selection pressures will endow complex organisms with capacities for behavioural plasticity, allowing them to adaptively allocate resources between somatic investment (continued growth and survival), current and future reproduction, offspring quantity and offspring quality (Roff 1992; Stearns 1992). Changes in mortality will affect the returns to this investment, whether in somatic maintenance or offspring (Chisholm 1993). Specifically, a higher risk of one's own mortality will increase the relative returns to investing in current

reproduction as opposed to future reproduction, given the lower likelihood of surviving to reproduce in the future. This may well entail increasing investment in offspring quantity rather than quality (as high quality offspring may require continued investment which will not be forthcoming in the event of parental mortality, particularly in species with long periods of parental investment such as our own). Both evolutionary and non-evolutionary minded research has demonstrated a link between perceived life expectancy and early childbearing in deprived communities (Geronimus 1996; Wilson and Daly 1997; Geronimus 1999; Chisholm, Quinlivan et al. 2005; Nettle 2010; Nettle 2011). As well as adult mortality, the nature of child mortality may also influence fertility behaviour, though the effects of higher offspring mortality may be dependent upon whether it can be influenced by the parent. Higher exogenous mortality (outside of parental control) is likely to induce the dilution of investment into more offspring (McNamara, Welham et al. 2004), whilst higher endogenous mortality (within parental control) may increase the returns from concentrating investment in a few offspring and maximising their chances of survival.

Empirical evidence for this mortality-fertility relationship has been gathered from non-humans. Eggers, Griesser et al. (2006) found that, in Siberian Jays *Perisoreus infaustus*, increasing perceived endogenous mortality risk (by playing back recordings of bird calls from a common nest predator) significantly decreased clutch size (number of eggs laid). The manipulations were in the mortality risk in the environment that the birds would *perceive*, there was no change in the actual mortality of the environment.

Previous studies looking at mortality perceptions in humans have also shown priming towards own and adult mortality has a pro-natal effect. We have already conducted one internet experiment, using undergraduates at a London university, which found significant context effects of adult mortality priming on the ideal number of children wanted by men, but not women (Mathews and Sear 2008). Arising from the very different theoretical perspective of Terror Management Theory (TMT) (Solomon, Greenberg et al. 1991; Pyszczynski, Greenberg et al. 1997), studies by psychologists on Dutch (Wisman and Goldenberg 2005), German (Fritsche 2007) and Chinese undergraduates (Zhou, Liu et al. 2008; Zhou, Lei et al. 2009) have also found that participants react to mortality primes by increasing their desire for children, as well as

other pro-natal measures. It is worth noting that the primes administered and the fertility preference data collected in these Terror Management studies were somewhat different to survey style items. The mortality primes, for example, were open-ended questions on the process of dying. In these Terror Management studies pro-natal effects were found after mortality priming for just males in the Wisman and Goldenberg (2005) study, but for both sexes in the other studies.

Mortality and morbidity primed context effects are a genuine risk in survey data. For example respondents in the DHS are asked in detail about child deaths and potentially fatal illnesses prior to the question "*If you could choose exactly the number of children to have in your whole life, how many would that be?"*[16] We think it is likely there are other context effects that could significantly influence fertility preferences, such as priming respondents to think about their career, pregnancy or old age. But here we are replicating our previous study using a wider range of both mortality primes and fertility preference measures, in order to test the robustness of these mortality context effects. Our study is only concerned with perceived mortality, not actual mortality, and the translation of the latter into the former is a complicated process (Montgomery 1998; Montgomery 2000; Carvalho 2005).

Data and methods

Our data were collected from an internet experiment using students at sixteen higher education institutions in southern England, which range in size and socio-economic recruitment.[17] Contact was made with an appropriate individual within each organisation and participants were then recruited either via an email to their student account, or via an invitation posted on the university / student union website. The questionnaire was described to participants as a 'survey' to conceal its experimental nature, though the final page provided debriefing information. Ethical clearance was

[16] Full details of the DHS are available at http://www.measuredhs.com/aboutsurveys/dhs/start.cfm
[17] These were: Bournemouth University, Brunel University, London Metropolitan University, Roehampton University, the University for the Creative Arts, University of Cambridge (Caius College), University of East London, University of Essex, University of Exeter, University of Greenwich, Birkbeck College, London School of Economics, School of Oriental and African Studies, University College London (Department of Geography), University of Southampton and the University of the West of England.

obtained from the LSE ethics committee and from the ethics committees of those participating institutions who deemed it necessary.

Participants were asked to complete an online survey which included questions on fertility preferences, mortality and socio-economic and background data. Data were collected between October 2008 and April 2009. We chose to only include data from childless students under the age of 40 as they will be at roughly similar life course stages and likely to be able to still have children. Due to the voluntary nature of participation our results should not be viewed as being representative of the student population of the UK. The appropriateness of convenient non-representative samples for running context effects experiments has generally been accepted by survey methodologists e.g. Strack and Martin (1987), though see Schuman (2009) for recent disagreement.

Here we report the effects of four different question ordering manipulations, which we refer to as 'treatments': i) The first treatment group received 11 preceding questions related to adult (and their own risk of) mortality prior to a battery of questions on fertility preferences, ii) the second group answered 11 questions on childhood mortality in the UK prior to the fertility items, iii) the third group did not answer any preceding questions but did answer one of the sets of priming questions after the fertility preferences measures and iv) the final group were asked 11 questions on visiting a dentist and their dental health before answering the fertility items. This last group was included as a secondary control for negative mood, as questions about dentistry would act as an unpleasant, yet non-lethal, prime. It would also control for attrition and fatigue as participants tire of answering questions per se.

The participants were randomly allocated between each of the groups; the only systematic difference between the groups is in the questions they answered before the fertility preferences items. We nevertheless asked participants about their family and socio-economic background to test whether any observed context effects were concentrated in particular subgroups. Specifically we collected information on their age, expected future income, parental education, country of birth, ethnicity, religiosity, partnership status, sibship size, experiences of mortality and the deprivation and life expectancy of the participant's local neighbourhood.

Construction of variables and model fitting

Details of the specific questions asked can be found in Appendix One (page 183). We analysed seven fertility items which we will refer to as Measures A-G.

The first question asked in the fertility preferences battery uses exactly the same wording as that used in the DHS on the ideal number of children. *"If you could choose exactly how many children to have over your whole life, how many would that be?"* We split the responses to this question in two. We will refer to the numeric responses when the respondent wants to have at least one child as Measure A. Measure B is a binary variable constructed from the same question but coded for whether the participants want to remain childless. This more appropriately reflects the two decisions being made when answering the question: 1) *Do I want to be a parent?* (captured by Measure B) and 2) *if yes, how many children do I want to have?* (captured by Measure A). The exact coding is set out below.

Answer categories	Measure A – Value contributed	Measure B – Value contributed
None – I would remain childless	Dropped from analysis for this measure	1
1 child	1	0
2 children	2	0
3 children	3	0
4 children	4	0
5 or more children	5	0
Cannot say	Not used in this analysis	Not used in this analysis
Prefer not to say	Not used in this analysis	Not used in this analysis

Measures C and D are two continuous aggregate scores for the pro/anti-natalism of participants, which uses ratings of 5 different family sizes on the basis of (C) how beneficial/costly the respondents thinks each family size will be (the expected utility of family size) and (D) how likely/unlikely the respondent thinks each family size will be. For Measure C the question was phrased as *"Looking at the options below please*

indicate on the scale the expected consequences for your overall wellbeing, fulfilment and satisfaction if you had this number of children (+5 being highly beneficial, 0 being neutral / uncertain and -5 being highly costly)"

The respondents were then presented with the below grid and were able to select one value from each row. The numbers in the italics represent the value that is contributed to the total score and were not present when the respondent was completing the question. Positive value indicates broadly pro-natal sentiments and negative values indicate anti-natal sentiments

	Highly Beneficial				**Neutral/ Uncertain**						**Highly Costly**
GIVEN SCORE	**5**	**4**	**3**	**2**	**1**	**0**	**-1**	**-2**	**-3**	**-4**	**-5**
I will not have any children	*-10*	*-8*	*-6*	*-4*	*-2*	*0*	*2*	*4*	*6*	*8*	*10*
I will have had one child	*-5*	*-4*	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*4*	*5*
I will have had two children	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
I will have had three children	*5*	*4*	*3*	*2*	*1*	*0*	*-1*	*-2*	*-3*	*-4*	*-5*
I will have had four children	*10*	*8*	*6*	*4*	*2*	*0*	*-2*	*-4*	*-6*	*-8*	*-10*

So if a respondent gave the following answers (the contribution towards the total score are given in the parentheses) then the total net score would be plus 4. The maximum score is + 30 and the minimum is – 30

	Highly Beneficial					**Neutral/ Uncertain**					**Highly Costly**
GIVEN SCORE	**5**	**4**	**3**	**2**	**1**	**0**	**-1**	**-2**	**-3**	**-4**	**-5**
I will not have any children									*X (6)*		
I will have had one child							*X (1)*				
I will have had two children			*X (0)*								
I will have had three children					*X (1)*						
I will have had four children								*X (-4)*			

Measure D (Parity specific likelihood grid measure) was calculated in the same manner except the preceding text was *"Of the following six options please indicate on the scale from +5 to -5 how likely it is that you will have had this number of children at the end of your reproductive life (+5 being highly likely, 0 being uncertain and - 5 being highly unlikely)."*

Measure E is a composite score for the pro/anti-natalism of respondents to a battery of Value of Children Likert items (as used in Nauck 2007). The preceding text was *"For each statement respondents can choose one of six options from: Strongly Agree, Agree Neutral, Disagree, Strongly Disagree, Cannot say."* With 'strongly agree' contributing 2 units and agree 1 unit. The direction of the values was determined by the pro-natal (reason for having children) or anti-natal (reason against having children) nature of the statement.

Statements	Contribution to Measure D
1) Children make life more exciting and fun	Pro-natal (Strong agree + 2, agree +1, disagree -1, strong disagree -2)
2) Children leave too little time for one's own interests	Anti-natal (Strong agree - 2, agree - 1, disagree + 1, strong disagree + 2)
3) Children are practical, because when you're older you have someone to take care of you	Pro-natal
4) Children create problems with neighbours, on trips and in public	Anti-natal
5) Children burden the relationship	Anti-natal
6) Children are a financial burden and reduce one's living standards	Anti-natal
7) Children give one a sense of being needed	Pro-natal
8) Children bring worries and problems	Anti-natal
9) Having children at home and watching them grow up is enjoyable	Pro-natal
10) Having children decreases the amount you can work	Anti-natal
11) it is good to have children because you can rely on them in an emergency	Pro-natal
12) Children bring partners in a relationship closer together	Pro-natal
13) When a women wants to have a career, she must do it without children	Anti-natal

Previous research has shown that there often multiple dimensions within this VOC scale on the basis of Affection, Utility, Cost (Henz 2008). However we decided to load onto just one dimension after conducting a principle components analysis looking at the items covariance. The principle components analysis showed that the first component was a tendency to agree (all loadings were in the same direction) and the second component the pro / anti-natal direction of the agreement. The cumulative

variance explain by the first two components exceed 40% for both males and females and had an eigen value's greater than 2. Each of the remaining components explained less than 10% to the variance and had eigen values of less than 1.3 and so by convention are not normally considered as explaining a 'significant' proportion of the variance (Bartholomew, Steele et al. 2008).

Finally, two questions on the timing of childbearing were asked: the number of years until the respondent would (F) ideally and (G) expect to have their first child.
For Measure F the questionnaire asked *"Taking into account your current age, how old would you LIKE to be when your first (next) child is born?"* The current age was subtracted from this value which gave a measure for the number of years until the respondents wanted their first (next) child to be born. Measure G was constructed in the same was above measure though using the question *"How old do you EXPECT to be when your first (next) child is born?"*

The construction of majority of the control variables was relatively straight forward, most being operationalised as a binary variable split at a logical position, such as the midpoint of the distribution. We asked at the end of the questionnaire whether the respondents were willing to provide the postcode of their current address, and over 65% provided a valid UK entry. Using this information we were able to match the postcode to the local Index of Multiple Deprivation (IMD) score as provide by the Department of Communities and Local Government. The IMD 2007 score is a composite of 37 different indicators that cover different dimensions of deprivation: Income, Employment, Health and Disability, Education, Skills and Training, Barriers to Housing and Services, Living Environment and Crime. As our context effects were related to mortality we also used the postcode to control for ward level life expectancies as provide by the Office of National Statistics.[18] Finally we included responses to a question on whether the respondent had experienced recent mortality. Whilst this was technically a 'priming' question it had also been included at the end of the dental health questionnaires after both the treatment and control questions.

[18] For more details on the construction of IMD and ward level life expectancy see
http://www.communities.gov.uk/documents/communities/doc/615986.doc
http://www.statistics.gov.uk/statbase/Product.asp?vlnk=14466

We then fitted separate multivariate Ordinary Least Squares (OLS) regression models (and a binary logit for Measure B) for each measure and each sex. This was because we expected differences in reactions to mortality priming from each sex, a result seen in our previous study (Mathews and Sear 2008), and this would simplify the analysis by reducing the need for numerous interaction terms. Dummy variables for each of the prior question treatment groups allowed us to compare each group to those who did not receive any preceding questions. We used multivariate models as they allow the use of numerous control variables. Whilst randomisation between the treatment groups means that there should not be systematic differences between them, there were some small differences between the treatment conditions in socio-economic variables (see Table 1). We checked the treatment effects using ANOVA and ANCOVA models, which showed similar results to those presented here. For all the variables (dependent, explanatory and control) we also checked that changes in the operationalisation and thresholds for the variable did not substantially alter the results.

We also considered models with a non-normal distribution for responses to the ideal number of children question. To analyse the bivariate relationship between treatment and the ideal number of children we used a Kruskal-Wallis test, this is a nonparametric procedure that does not require the assumption of normality, and so may be more be more appropriate for responses to this question. Poisson and negative binomial models are often used for multivariate regression analysis on non-normal count data. However as we divided the question into two components Measure A did not contain any ‘zero’ observations and so we were not able to run poisson or negative binomial models. We did however run the OLS model with a log version of the Measure A as the explanatory variable. This yielded similar results to those presented here.

Finally looked at the correlation between the measures and used a MANOVA (multivariate analysis of variance) test to look at the overall effect of the treatment. A MANOVA test is a special case of ANOVA that assess the effect of categorical independent variables on a vector that combines all of the continuous dependent variables together, in effect testing whether the treatments affected *all* of the fertility preferences measures. A MANOVA test provides four test statistics to assess the

significance of the association i) Wilks' lambda ii) Lawley-Hotelling trace iii) Pillai's trace iv) Roy's largest root. Significance is assessed considering the results of all four test statistics. All analysis was conducted using STATA 11.

Results

In total 1393 childless females and 583 childless males participated in the relevant parts of the experiment: a lower response rate for males is regularly found in studies of this nature (Sax, Gilmartin et al. 2003). We did not find any evidence for reverse priming using chi-squared tests (i.e. fertility preference questions did not influence responses to the mortality priming or dental health questions) so we were able to pool the respondents who had not received any preceding questions. The control variables showing the respondents' socio-economic background are described in Table One (results tables are on pages 177-182). The distribution of answers to the DHS ideal number of children question for each of the preceding question treatments is given in Tables Two and Three for men and women respectively. This shows substantial volatility between the different groups. The Kruskal-Wallis test shows a significant bivariate association between the preceding questions and the responses for males at the 5% level ($p=0.043$) but not for females ($p= 0.239$).

Table Four shows the multivariate results for each of the fertility preference measures individually modelled with the same control variables. Our respondents are not representative of any demographic grouping so to avoid confusion we do not present the control variable coefficients. Of the control variables, significant effects were only observed for age, religiosity, sibship size, and partnership but these were in a manner in keeping with the existing literature (i.e. generally the fertility preferences declined with age and increased with religiosity, sibship size and having a partnership).

The first column in Table Four shows the results for Measure A (the ideal number of children question). Priming with adult mortality significantly increases the reported ideal number of children for males, but there was not a significant effect for females. This replicates our previous finding (Mathews and Sear 2008). Neither sex reported a significantly different ideal number of children if primed with preceding items on

child mortality. Somewhat unexpectedly, preceding questions about dental health marginally significantly decreased the reported number of children desired by females.

We tested for interactions between the treatment and control variables. These interactions proved to be non-significant or have extremely large and non-credible effect sizes (due to small cell sizes), suggesting that the treatments had similar effects across all individuals, regardless of socio-economic characteristics.

There were relatively strong correlations between the measures (numerous correlation coefficients exceeding 0.1: see Tables Five and Six). Despite this there was only one other fertility preference measures (Measure B) that suffered a context effect that was significant at the 5% level. The desire for childlessness (a component of the ideal number of children question) was increased in males after priming with child mortality. There were however five other measures were the treatment effect was marginally significant at the 10% level. For males, child mortality primes marginally decrease the reported number of years until they would ideally start childbearing (Measure G) whilst dental health questions marginally increase a desire for childlessness (Measure B). For females, adult mortality questions seemed to increase a desire for childlessness (Measure B) and this was only just outside of conventional significance ($p=0.052$). This measure was also marginally increased by preceding questions on dental health. Dental health primes also marginally decrease females' aggregate Value of Children score (Measure E).

None of the four MANOVA test statistics for the relationship between all of the continuous dependent variables and the treatments were statistically significant (results not shown). This further suggests that there was *not* an aggregate treatment effect, and the preceding question context effects were only influencing some of the fertility preferences measures.

Discussion

Fertility decisions are highly context dependent. We therefore expected attitudes pertaining to future fertility to be at risk of suffering from preceding question context

effects. Here we have shown that a widely employed question about the number of children an individual would ideally like to have will generate significantly different answers according to the nature of the preceding questions. It should be noted that our preceding priming questions were designed with the intention of influencing respondents. Our priming questions have not actually been used in a social survey, and are quite different to the types of questions commonly asked the UK surveys. They are, however, not so different to the questions asked in the DHS.

We found, as has been shown in our previous work, evidence that men's ideal family sizes (Measure A) increase after priming with adult mortality. In context effect experiments replication is important and Bishop, Oldendick et al. (1985) showed that some context effects are not easily replicated. The robustness of the adult mortality prime increasing the ideal number of children for young males but not females in both this and our previous study (which used an almost identical methodology), and elsewhere (Wisman and Goldenberg 2005) suggests that this is a genuine effect.

This effect at least partially fits with our prediction that mortality salience will alter fertility preferences, in line with both evolutionary theory and demographic observation. It also fits with Terror Management Theory. This theory emphasises the cognitive difficulties in accepting the dissolution of self, and so mortality primes induce individuals to seek an 'immortality of self', by projecting their identity onto their wider social group. This means that own mortality primes are said to orientate individuals towards more traditional social norms (Solomon, Greenberg et al. 1991), which could include family values and raising children. Note that none of the three approaches – evolutionary, demographic or psychological Terror Management are necessarily mutually exclusive.

One potential explanation for the difference between males and females is that they differ in their prior consideration of fertility. Menstruation, menopause and the normally unequal burden of childcare should make females more aware of their fecundity and its potential consequences, and so perhaps have more concrete, less malleable preferences. It is noted in the survey methodology literature that weakly held and more fluid attitudes are at greater risk of context effects (Tourangeau, Rips et al. 2000). However, whilst prior consideration of childbearing is higher for our female

respondents (see table one) we do control for this variable in the model and it is not a significant predictor of the ideal number of children. Moreover four of the females' preference measures were marginally affected by some of the primes.

Terror Management psychologists Wisman and Goldenberg (2005) have argued that for Western European women, mortality primes may not induce higher fertility preferences as child raising may compromise their capacity to achieve 'social immortality' through their career. We do not find this explanation wholly satisfactory: career orientated females are often going against established social norms and we are dubious about whether most females would expect their employment genuinely to generate 'social immortality'.

Our a priori expectations were generated from life history theory. From this perspective adult mortality priming may have a greater effect on male fertility preferences because of underlying biological difference between the sexes. Reproduction for a female depends upon successful gestation and lactation of the offspring, whilst for males a continued post-insemination presence is not essential for reproductive success (Mathews and Sear 2008). This might mean males have greater plasticity in their reproductive strategies, and that their fertility preferences are more sensitive to changes in their perceived environment. We would reiterate that life history theory makes no assumptions about the conscious nature of responses.

We also observed some 'new' effects in our other primes and preference measures. Desired childlessness seemed to be increased in males primed with child mortality and in females primed with adult mortality. Notably and unexpectedly, we found that preceding items on dental health had a marginally significant effect upon four of the fertility preference measures. Without replication we remain cautious about concluding that any of these effects are genuine. We had an a priori theoretical reasoning for believing that mortality priming would influence fertility attitudes, which was partially supported. The dental health questions were included only as a secondary control and we did not expect them to influence fertility preferences. Due to the effect of the dental health primes we are not able to rule out that all the observed priming questions effects are partly due to fatigue or negative mood, though we would be very interested to see if it is actually possible to replicate the dental

health effects. If prior questions on dental health do genuinely alter the responses given, then this expands the range of question topics that potentially risk altering later fertility preference items.

The most convincing evidence for context effects (those significant at the 5% level) tended to involve the ideal number of children question (Measures A and B). Miller and Pasta (1995) have suggested that questions on the ideal total number of children are less reliable than other fertility preference measures. Philipov (2009) has also made this point, arguing that *idealised* fertility attitudes, without reference to constraints, are almost by definition not meant to be realistic. Such ideal number of children questions could be considered as useful as asking participants in a study how much they would 'ideally' like to be paid in their future employment! Part of our reason for replicating our previous internet experiment on fertility preferences (Mathews & Sear 2008) was to include more 'sensitive' indicators of fertility preferences, such as those on timing and the Value of Children. However, the ideal number of children question was actually the most affected by context. Nevertheless, just because the responses to this question seem to change after preceding questions does not mean that ideal number of children items do not have any utility. The highly responsive nature of this item means that it could be useful for psychologists seeking to understand subtle influences on fertility attitude formation, and it should also be remembered that the ideal number of children question does successfully predicted some future fertility (Bankole and Westoff 1998)

Another explanation is that the ideal number of children question was also the first item in the fertility preferences section. Context effects are sometimes only found on the first item in a battery and not on later ones, for example Smith (1991). Tourangeau, Singer et al. (2003) discuss both immediate and remote context effects, and some primes will not have enduring effects. It would be useful to alter the ordering within the fertility preferences battery and see if this changes the resistance of the items to context effects. Indeed it would be interesting to see if within the fertility preferences battery there are internal context effects, certainly it is plausible that asking the Value of Children questions earlier could influence later responses to more direct fertility preference items. We are therefore cautious about concluding that

it is only items asking about ideal numbers of children that are at risk of context effects.

Finally, it is important to set out that the results could be the product of sheer chance. Internet experiments have become increasing popular in psychology (Krantz and Dalal 2000). The ease with which it is possible to obtain substantial randomised data does come at a potential cost of increased heterogeneity in the participants. Increasing the diversity of participants increases the risk that the randomly allocated groups do contain differences in their background characteristics. For example, 66% of females in the dental health condition had a parent who had attended university, somewhat higher than the 57-60% observed in the other treatment conditions. We did, however, use multivariate techniques to try to compensate for this effect. We consider this reinforces our point about the value of replication in these types of experiment.

General discussion

The key argument that we wish to make is that whilst the accurate measurement of fertility preferences is important for understanding actualised fertility and for informing public policy, findings from such questions must be interpreted carefully. Fertility preference measures lack what social psychologists call 'attitude strength' (Krosnick, Boninger et al. 1993). 'Strong' attitudes will i) persist over time, ii) have a strong impact on information processing / behaviour and iii) be resistant to change (Krosnick and Petty 1994). Previous studies have shown that an individual's fertility preferences changes over time as their external context changes, and that they do not have particularly strong predictive power. We have shown here that some are also not resistant to change as preceding questions seem to alter the responses given.

Preceding questions can have important effects upon the reporting of opinions. Experimental psychology employs 'counterbalancing' in attitudinal measurement by regularly changing question ordering (Goodwin 2010). But other disciplines that are more reliant on survey data, including demography, do not seem to have appreciated this potential vulnerability in attitudinal measures. Question ordering effects may be less problematic if the key requirement is to shows trends over time in responses to the same question in a longitudinal survey, *if the preceding questions remain the same*

in each wave of the survey. However, preceding questions often do not remain the same across all waves of a study. We recommend that researchers consider reporting the previous questions to their fertility preference items as a matter of good practice.

We should note again that our participants are not a representative sample. Whilst we did not find any viable or significant interactions it remains a possibility that different socio-demographic groups vary in their risk of context effects. We will not attempt to conclude that particular fertility preference items are 'better' or 'worse'. There may well be variance in the extent that particular items are at risk of context effects. Ideally numerous indicators could be deployed, though of course each extra item included within a survey generates additional expense. Not every fertility preference measure will be influenced by its preceding questions, indeed most of the items in this experiment did not show a significant effect. The intention of this paper is simply to highlight that the plausibility that some fertility preference items might be at risk.

As well as arguing for careful interpretation, our second recommendation is for more research into the accurate measurement of fertility preferences, and in particular into the effects of preceding questions. With the general transition of social surveys to computer aided data collection it has become relatively easier to run experimental manipulation of question ordering as part of the collection process. Here we have only shown context effects related to mortality or dental health primes. We consider it highly likely that there are others. We hope future research will look at other possible primes, for example preceding questions on career, social interactions, pregnancy or old age support could all theoretically influence the reporting of fertility preferences.

The utility of fertility preference questions depends on their intended use, be it for prediction or policy. They do have a potentially important role to play in both. But we believe it is vital that more research is undertaken into the factors, such as question ordering, that influence their measurement.

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Table 1: Descriptive values for control variables by treatment group for all childless participants under the age of 40

	Males				Females			
Categorical control variables n and (%)	Adult mortality	Child mortality	Dental Health	Control	Adult mortality	Child mortality	Dental Health	Control
Expected income in 5 years: Over £30K	34 (41.98)	36 (47.37)	37 (53.62)	166 (47.16)	57 (32.76)	59 (36.88)	62 (33.88)	264 (30.56)
A Parent attended University: Yes	53 (65.43)	53 (69.74)	46 (66.67)	227 (64.31)	101 (57.71)	91 (56.52)	120 (65.57)	520 (60.19)
Country of Origin: Non UK	28 (34.57)	32 (42.11)	23 (33.33)	131 (37.11)	56 (32.00)	54 (33.54)	60 (32.79)	294 (34.03)
Ethnicity: Non White	17 (20.99)	16 (21.05)	12 (17.39)	71 (20.11)	38 (21.71)	37 (22.98)	38 (20.77)	172 (19.91)
Partnership status: Single	48 (59.26)	44 (57.89)	39 (56.52)	217 (61.47)	79 (45.14)	75 (46.58)	83 (45.36)	395 (45.72)
High prior consideration of desired numbers of children	17 (20.99)	22 (28.95)	11 (15.94)	95 (26.91)	70 (40.00)	71 (44.10)	77 (42.08)	339 (39.24)
Have experienced death of a close family or friend in the last five years	39 (48.15)	37 (48.68)	46 (66.67)	164 (46.46)	98 (56.00)	91 (56.52)	90 (49.18)	457 (52.89)
Postcode (IMD and Life Expectancy) missing	22 (27.16)	28 (36.84)	28 (40.58)	114 (32.29)	56 (32.00)	51 (31.68)	58 (31.69)	272 (31.48)
Continuous Control Variables: Mean and (standard deviation)								
Age	22.46 (4.03)	22.53 (3.73)	22.87 (5.02)	22.96 (4.66)	23.5 (5.28)	23.08 (5.23)	22.43 (3.41)	22.60 (4.23)
Religiousity: Scale 0 (least religious) to 6 (most religious)	1.35 (1.87)	1.36 (1.68)	1.14 (1.7)	1.61 (2.09)	1.46 (1.83)	1.81 (2.09)	1.96 (2.17)	1.58 (1.9)
Number of siblings (0-4)	1.54 (0.9)	1.45 (0.97)	1.68 (1.09)	1.75 (1.08)	1.82 (1.19)	1.81 (1.22)	1.6 (1.01)	1.64 (1.05)
Life expectancy of ward in years	78.84 (2.3)	78.3 (2.16)	78.37 (2.42)	78.26 (2.33)	78.53 (2.28)	78.42 (2.36)	78.68 (2.72)	78.29 (2.27)
IMD score of current neighbourhood	18.50 (14.63)	20.62 (9.74)	18.41 (12.56)	22.33 (12.72)	20.43 (12.72)	19.85 (12.74)	21.48 (14.25)	21.84 (12.73)

Table 2: Males: Distribution of ideal number of children by question ordering treatment

	Question preceded by a series of items on…			
Ideal number of children	Adult mortality	Child mortality	Dental health	No preceding questions
0	5 (6%)	12 (16%)	9 (13%)	23 (7%)
1	3 (4%)	4 (5%)	2 (3%)	19 (5%)
2	32 (39%)	29 (38%)	33 (46%)	145 (41%)
3	28 (34%)	28 (28%)	15 (21%)	99 (28%)
4	6 (7%)	3 (4%)	4 (6%)	34 (10%)
5	6 (7%)	4 (5%)	1 (1%)	8 (2%)
Cannot say / missing	2 (2%)	3 (4%)	8 (11%)	25 (7%)
N	82	76	72	353

Table 3: Females: Distribution of ideal number of children by question ordering treatment

	Question preceded by a series of items on…			
Ideal number of children	Adult mortality	Child mortality	Dental health	No preceding questions
0	22 (12%)	15 (9%)	19 (10%)	57 (7%)
1	5 (3%)	6 (4%)	1 (5%)	40 (5%)
2	74 (42%)	66 (40%)	81 (43%)	335 (39%)
3	46 (26%)	36 (22%)	48 (26%)	225 (26%)
4	21 (12%)	30 (18%)	21 (11%)	107 (12%)
5	7 (4%)	9 (5%)	5 (3%)	38 (4%)
Cannot say / missing	3 (2%)	2 (1%)	3 (2%)	62 (7%)
N	178	164	187	864

Table 4: Results of regression models correlating treatment group with fertility preference measures for each measure of fertility preferences

	A: Ideal number of children (1-5)		B: Desires Childlessness (Logit)		C: Expected Utility (+ benefit high parity, - benefit low parity)		D: Likelihood (+ likely high parity, - likely low parity)		E: Value Of Children (+ beneficial, - costly)		F: Years until expected childbearing		G: Years until ideal childbearing	
	coef	p	coef	p	coef	p	coef	p	coef	p	coef	p	coef	p
MALES *Omitted category: No prior questions asked*														
Adult (own) mortality	0.23**	0.034	-0.40	0.501	1.55	0.309	1.23	0.412	-0.29	0.688	0.209	0.576	-0.34	0.310
Child mortality	0.54	0.649	1.03**	0.011	-0.49	0.758	-1.47	0.346	0.914	0.214	-0.03	0.939	-0.68*	0.062
Dental health	-0.050	0.702	0.848*	0.062	-2.07	0.223	-1.88	0.260	0.246	0.752	-0.05	0.902	-0.06	0.874
n	478		555		543		541		563		471		519	
FEMALES *Omitted category: No prior questions asked*														
Adult (own) mortality	-0.05	0.502	0.56*	0.052	0.27	0.800	-0.06	0.958	-0.17	0.74	-0.16	0.487	-0.23	0.272
Child mortality	-0.05	0.543	0.31	0.326	0.11	0.922	1.758	0.103	-0.03	0.99	-0.018	0.936	0.28	0.182
Dental health	-0.13*	0.092	0.55*	0.062	-0.26	0.769	-1.43	0.162	-0.90*	0.083	-0.017	0.937	-0.15	0.449
n	1182		1306		1323		1280		1359		1162		1237	

*** p<0.01, ** p<0.05, * p<0.1 Controlling for Age, Expected Income, Parental education, Country of origin, Ethnicity, Religiosity, Partnership status, Prior consideration of childbearing, Total sibship size, Recent experienced of mortality, Life expectancy and Index of Multiple Deprivation score for participant's current address. Dummy variables used for missing values

Table 5: Correlation matrix of dependent variables used in the models - Childless Males (non-missing n=428)

	A: Ideal Children	C: Expect Utility	D: Likel'd	E: VOC	G: Expect age	F: Ideal age
A: Ideal Number of Children(+pro-natal / - anti-natal)	1					
C: Expected Utility of children (+ pro-natal / - anti-natal)	0.53	1				
D: Likelihood of having children (+ pro-natal / - anti-natal)	0.54	0.58	1			
E: Value of Children (+ children beneficial / – children costly)	0.15	0.32	-0.28	1		
F: Years Until Ideal Childbearing (+ anti-natal / - pro-natal)	-0.21	-0.10	-0.19	-0.10	1	
G: Years Until Expected Childbearing (+ anti-natal / - pro-natal)	-0.14	-0.08	-0.21	-0.10	0.79	1

Table 6: Correlation matrix of dependent variables used in the models - Childless Females (non-missing n=1018)

	A: Ideal Children	C: Expect Utility	D: Likel'd	E: VOC	G: Expect age	F: Ideal age
A: Ideal Number of Children(+pro-natal / - anti-natal)	1					
C: Expected Utility of children (+ pro-natal / - anti-natal)	0.55	1				
D: Likelihood of having children (+ pro-natal / - anti-natal)	0.58	0.60	1			
E: Value of Children (+ children beneficial / – children costly)	0.24	0.33	0.38	1		
F: Years Until Ideal Childbearing (+ anti-natal / - pro-natal)	-0.14	-0.13	-0.07	-0.09	1	
G: Years Until Expected Childbearing (+ anti-natal / - pro-natal)	-0.09	-0.08	-0.08	-0.07	0.8211	1

Appendix One: Priming questions

	Adult (own) mortality	**Child mortality**	**Dental health**
1	Please can you rank in order what you believe to be the most significant causes of death in the UK, with 1 being the cause which is responsible for the highest number of deaths to 5 which causes the lowest number of deaths Answer categories • Accidents / Injuries • Cancers • Circulatory failures (e.g. heart attacks) • Diseases of the digestive system • Infectious diseases (Influenza, HIV/AIDS, TB) • Cannot say (please just include 1 in this field and leave the rest blank)	Please can you rank in order what you believe to be the most significant causes of death *for children and infants under the age of 5* in the UK, with 1 being the cause which is responsible for the highest number of *childhood* deaths to 6 which causes the lowest number of deaths Answer categories • Accidents / Injuries • Cancers • Circulatory failures (e.g. heart attacks) • Diseases of the digestive system • *Premature birth* • Infectious diseases (Influenza, HIV/AIDS, TB) • Cannot say (please just include 1 in this field and leave the rest blank)	Below are six reasons why people have dental health problems. Please can you rank in order what you believe to be the leading causes of dental health problems in the UK, with 1 being the cause which is responsible for the highest number of cases to 6 which causes the lowest number of cases. Answer categories • Insufficient teeth cleaning using a toothbrush • Insufficient teeth cleaning using dental floss • Not using a toothpick and or sugar free chewing gum after eating meals • Excess consumption of sugary drinks • Excess consumption of sugary foods • Insufficient consumption of high calcium foods and drink (milk and cheese) • Cannot say (please just include 1 in this field)

2	Relative to your friends and family, how easily do you become upset at images of death in the media (fictional and non-fictional)? Answer categories • Much more easily upset • Slightly more easily upset • Neutral • Slightly less easily upset • Much less easily upset • Cannot say • Prefer not to say	Relative to your friends and family, how easily do you become upset at images of *children dying* in the media (fictional and non-fictional)? Answer categories • Much more easily upset • Slightly more easily upset • Neutral • Slightly less easily upset • Much less easily upset • Cannot say • Prefer not to say	Approximately how long ago was it that you last visited a dentist? Answer categories • Under 6 months • 6-12 months • 1-2 years • More that 2 years ago • I have never visited a dentist • Cannot say • Prefer not to say
3	Approximately how many adult deaths are there in the UK every year? Answer categories • Under 200,000 • 200,000 - 400,000 • 400,000 – 600,000 • 600,000 – 800,000 • 800,000 – 1,000,000 • Over 1,000,000 • Cannot say	Approximately how *many children under the age of 5* die in the UK every year? Answer categories • Under 500 • 500 – 2,000 • 2,000 – 3,500 • 3,500 – 5,000 • 5,000 – 6,500 • Over 6,500 • Cannot say	Of the following which best describes the purpose of your last visit? Answer categories • Routine check up • Dental braces (fitting, removal or check up) • Teeth whitening / Oral hygienist • Dental restoration (cavity filling) • Major dental surgery (root canal surgery, dental extraction) • Other procedure • Cannot say • Prefer not to say

4	To what extent do you believe life expectancy in the UK is going to increase or decrease over the next 10 years? Answer categories • Highly likely to increase • Slightly likely to increase • Will remain unchanged • Slightly likely to decrease • Highly likely to decrease • Cannot say • Prefer not to say	To what extent do you believe the risk of dying for children in the UK is going to increase or decrease over the next 10 years? Answer categories • Highly likely to increase • Slightly likely to increase • Will remain unchanged • Slightly likely to decrease • Highly likely to decrease • Cannot say • Prefer not to say	Approximately how long ago was it between your last visit and the time before that? Answer categories • Under 6 months • 6 -12 months • 1 -2 years • More that 2 years ago • Cannot say • Prefer not to say
5	In the last 3 years have you experienced the death of any close friends or family members? Answer categories • Yes • No • Prefer not to say	In the last 3 years have you experienced the death of any close friends or family members? Answer categories • Yes • No • Prefer not to say	Thinking back to your last visit how many people accompanied you? (e.g. parents, siblings, friends) Answer categories • Zero - I went by myself • 1 person • 2 people • 3 or more people • Cannot say

6	If yes, in what age range was that individual(s) at the time of their death. *(select all that apply)* Answer categories • Under 5 • 5 -16 • 16 - 59 • 60 - 79 • Over 80 • Cannot say • Prefer not to say	If yes, in what age range was that individual(s) at the time of their death. *(select all that apply)* Answer categories • Under 5 • 5 -16 • 16 - 59 • 60 - 79 • Over 80 • Cannot say • Prefer not to say	As a consequence of your last visit did you make any of the following changes to improve your dental health *(select all that apply)* Answer categories • Increased frequency with which you brush your teeth • Increased frequency with which you floss your teeth • Increased use of mouth wash • Increased use of toothpicks or sugar free chewing gum after eating meals • Only drinking sugary drinks at meal times • Decreased consumption of sugary food and drink • Increase consumption of high calcium food and drink (milk and cheese) • None of the above • Cannot say

7	IMAGINATION EXERCISES You will now be asked to imagine two different scenarios and you will be asked several questions about each scenario. These are simply psychological exercises. Please just respond with the first thoughts that come into your mind. EXERCISE ONE Please can you spend four to five seconds imaging a scenario in which you are just about to die Some typical locations for this scenario are listed below. Please select which of the locations most closely resembles the one that you imagined. Answer categories • In a hospital ward • A room within your family home • Inside another building • Outside • Cannot say • Prefer not to say • Other	IMAGINATION EXERCISES You will now be asked to imagine two different scenarios and you will be asked several questions about each scenario. These are simply psychological exercises. Please just respond with the first thoughts that come into your mind. EXERCISE ONE Please can you spend four to five seconds imaging a scenario in which a child is just about to die Some typical locations for this scenario are listed below. Please select which of the locations most closely resembles the one that you imagined. Answer categories • In a hospital ward • A room within your family home • Inside another building • Outside • Cannot say • Prefer not to say • Other	From the below list please select an answer that best describes your emotional state prior to your last visit to a dentist Answer categories • Highly anxious • Slightly anxious • Neutral (neither anxious nor relaxed) • Slightly relaxed • Highly relaxed • Cannot say • Prefer not to say

8	In this scenario how many other individuals are present? Answer categories • 0 • 1 • 2 • 3-4 • More than 5 • Cannot say • Prefer not to say	In this scenario how many other individuals are present? Answer categories • 0 • 1 • 2 • 3-4 • More than 5 • Cannot say • Prefer not to say	Approximately how much where you charged for your last visit? Answer categories • Nothing - I was eligible for free treatment from the state • Nothing – the treatment was paid for out of private insurance • Less than £20 • £20 - £50 • More than £50 • Cannot say
9	What age do you expect to be when you die? Answer categories • Less than 64 • 65-69 years • 70-74 years • 75-79 years • 80-84 years • 85-89 years • 90-94 years • Over 95 years • Cannot say • Prefer not to say	What is the most common age of death for children that die in the UK before their 5th birthday? (Note: the time periods are not equal) Answer categories • Under 7 days • 8 - 28 days • 1 – 12 months • 1 – 5 years • Cannot say • Prefer not to say	In which country did your last visit to a dentist take place? Answer categories • England • Wales • Scotland • Northern Ireland • Other EU country • Other MEDC country • Other LEDC country • Cannot say • Prefer not to say (+ International Monetary Fund definition of MEDC)

10	EXERCISE TWO Please you can spend four to five seconds imaging the scenario of your funeral. Exercise Two: Again please answer with the first response that comes to mind. Some typical events for this scenario are listed below. Please select the one which most closely resembles what you imagined. Answer categories • Burial • Cremation • Cannot say • Prefer not to say • Other	EXERCISE TWO Please you can spend four to five seconds imaging the scenario of a child's funeral. Again please answer with the first response that comes to mind. Exercise Two: Again please answer with the first response that comes to mind. Some typical events for this scenario are listed below. Please select the one which most closely resembles what you imagined. Answer categories • Burial • Cremation • Cannot say • Prefer not to say • Other	IMAGINATION EXERCISE You will now be asked to imagine a scenario and you will be asked several questions about this scenario. This is simply a psychological exercise. Please just respond with the first thoughts that come into your mind. -------- EXERCISE ONE Please you can spend ***four to five seconds*** imaging a scenario in which you are just about to undergo dental treatment. --------- Some typical locations for this scenario are listed below. Please select which of the locations most closely resembles the one that you imagined. • At your regular dental surgery • At another dental surgery • In a hospital ward • A room within your family home • Cannot say • Prefer not to say • Other

11	In this scenario how many other individuals are present? Answer categories • 0 • 1-2 • 3-4 • 5-9 • 10-19 • More than 20 • Cannot say • Prefer not to say	In this scenario how many other individuals are present? Answer categories • 0 • 1-2 • 3-4 • 5-9 • 10-19 • More than 20 • Cannot say • Prefer not to say	In this scenario how many other individuals are present? Answer categories • 0 • 1 • 2 • 3-4 • More than 5 • Cannot say • Prefer not to say

CONCLUSIONS

The main empirical conclusions of the thesis are i) that kin positively influence the transition to first and second birth ii) fertility preference measures are at risk of being influenced by preceding questions. Many of the more direct implications of these findings have been covered in the papers themselves but the thesis is inter-disciplinary and has other wider implications for several academic disciplines. The results are also relevant for policy makers, and the second section of this chapter will deal with this area.

1. Academic implications

1.1. Understanding fertility

The primary motivation behind this thesis was to improve our understanding of fertility and fertility preferences. It has made a contribution to the demographic literature by showing that kin relationships and perceived mortality are factors that influence fertility decision making in contemporary Britain. Such variables have not previously been given much weight in fertility analysis, and could prove fruitful in improving our understanding of fertility variation and perhaps fertility forecasting in other settings. Though there is still a great deal more research that can be done into individual-level variance in fertility. Pseudo R-square figures for both the first birth and second birth papers indicate that only around 15% of the variance is explained in the full models including numerous independent variables.

As set out in the introduction, predicting future fertility levels is extremely difficult and expert opinions have regularly been incorrect. The context effects paper looks at the challenges of obtaining an accurate measurement of fertility preferences, and so highlights the difficulty of using these indicators to inform fertility assumptions in population projection models.

Some of the implications of the thesis could help fertility forecasting. From the final paper there is the relationship with perceived mortality. I am uncertain about the authenticity of some of effects from some of the primes, such as the anti-natal effects of the dental health

priming. But increasing perceived adult (own) mortality does appear to consistently increase fertility preferences in males. It is very important to stress that the translation of males' preferences into actualised fertility is far from straight forward (Montgomery 1998; Carvalho 2005), but assuming that changes in preferences do lead to changes in behaviour then following events that heighten perceived mortality it could be predicted that fertility rate should increase. Certainly, previous research has shown that terrorist attacks (Rodgers, Craig et al. 2005) and natural disasters (Cohan and Cole 2002) have resulted in higher subsequent fertility.

The first two papers show the positive influence of kin upon fertility, and this too may help fertility predictions, as changing inter-familial relationships could be a precursor to changing fertility rates. Whether developed societies have actually been experiencing a decline in kin orientation is not clear. Certainly McPherson, Smith-Lovin et al. (2006) found that in the US whilst overall social network sizes have decreased the decline in kin networks has been far less severe than that in non-kin networks. Regardless, if a substantial weakening in inter-family interactions does occur then it would be predicted that the birth rate would also fall.

This work also feeds into the literature on understanding historical fertility changes. Mortality decline has been the 'classic' implicit cause of fertility decline in the standard demographic transition model (Kirk 1996). As I have set out elsewhere (Mathews and Sear 2008) the classic demographic transition model does not explore psychological reasons why higher mortality should induce pro-natal fertility decision making. In as much that demographers have factored mortality into their understanding of fertility decision making, it has been through conscious replacement and insurance effects. The work presented in the final paper further supports a more complex and *not necessarily conscious* psychological link between perceived mortality and fertility. Papers one and two also have relevance for historical fertility decline debates. Some prominent attempts by evolutionary theorists to explain the demographic transition have argued that decreasing kin influence is at least partially responsible for fertility declines (Turke 1989; Newson, Postmes et al. 2005). The work presented here suggests that within contemporary British society women with weaker kin influence also have lower fertility.

1.2. Understanding social networks

The first two papers have implications for our understanding of wider social processes. Whilst the methods were similar for the first two papers, they were written for different audiences, with paper one being written to explicitly link into the social network literature. Social network research is a widely developing field and it has been shown that many characteristics of a social network influence a whole range of behaviours from employment (Granovetter 1973) to obesity (Christakis and Fowler 2007) to recreation (Putnam 1995). This approach is gaining greater acceptance in the health literature (Berkman, Glass et al. 2000) though there have also been criticisms as well (Cohen-Cole and Fletcher 2008). Demographers have predominately looked at social network effects upon contraceptive use, though two existing studies have shown that fertility does spread through social networks; co-workers in Sweden (Hensvik and Nilsson 2010) and siblings in the United States (Kuziemko 2006). The first two papers included in this thesis emphasise the importance of examining the kin orientation of social networks. Despite concern over the general decline in core social network size seen over the last few decades (regardless of their kin orientation (Putnam 1995; McPherson, Smith-Lovin et al. 2006), an interesting finding from the first two papers is that the general frequency of contact a woman has with her close friendship group (ignoring the group's kin orientation) has hardly any effect upon her risk of having a first or second birth. Instead, the first two papers show that is it contact with kin which really matters for fertility.

Whilst I have demonstrated that kin influence fertility, it should be remembered that the relationship between demographic characteristics and family availability will also work in the opposite direction. Low fertility and lower mortality will shape the kinship structure into a 'beanpole' (Bengtson, Rosenthal et al. 1990). Low fertility will reduce the number of siblings, aunts, uncles, nieces, nephews and cousins. Lower mortality on the other hand will increase the availability of parents, grandparents and great grandparents.

1.3. Data collection

The context effect research used a fairly innovative internet based approach to collecting data. Online research methods are a relatively new and it is likely that data collected in this

manner will grow in importance in the future. Internet-based research has the benefits of being able capture large volume of information cheaply and quickly. However there are also problems, in particular internet based studies such as mine lack a valid sampling frame, and as stressed in the paper, cannot be said to representative (Dillman 2000; Hunsinger, Allen et al. 2011). The internet may provide more fertile ground for randomised experiments such as the one outlined here, particularly if the experimental manipulations are relatively subtle, such as differences in question wording or ordering. There seems to be substantial utility for survey designers and methodologists to routinely use online experimentation to test and pilot their questionnaires. Demographers have rarely used randomised experiments, though they may be useful for understanding fertility decision making. Internet experiments are becoming more common in psychology but as far as I am aware my final paper is one of the first written explicitly for a demographic audience to collect data in this manner.

2. Policy implications

The work conducted for this thesis as implications for three broad areas of policy. The policy implications of the final paper regarding the difficulties measuring fertility preferences for the justification of pro-natal fertility policies are relatively well developed in the paper. Here I will focus more on the implications of the analysis of the first two papers.

2.1. Kin-provided childcare and female labour force participation

One of the major changes of the second half of the 20th century was the increase in the participation of females in the labour force. There have been many extremely positive consequences. At a macro-economic level greater labour force participation increased inputs into the economy and stimulated growth. Empirical studies consistently show that in advanced economies recent female cohorts have been better or at least equal to males in accumulating human capital (Buchmann, DiPrete et al. 2008; Breen, Luijkx et al. 2010), thus further enhancing growth. At the individual level the UN specifically includes female economic participation as a component within its Gender Empowerment Measure and there are also associations seen between a female's employment status and her happiness

and health (Repetti, Matthews et al. 1989; Blanchflower and Oswald 2002) (though of course with debate about the direction of causality). Given the macro and micro benefits Janssens (1997) argues that it is highly likely that the Western male breadwinner model of the mid-20th century will come to be seen as an aberration.

However, increasing (re-establishing) female labour force participation is not without its challenges, particularly for mothers with young children. There has been a long standing interest in the trade-offs in time use between domestic work and paid employed (Becker 1965). Male partners' contributions have potential to increase on the domestic side, but there is growing recognition that social policy has a role in improving time poverty as much as income poverty (Fitzpatrick 2004; Goodin, Rice et al. 2005). Parents are more likely to be 'time poor' (Burchardt 2008) with this problem being more acute in dual-earning households. This presents an opportunity for relatives to assist in childcare. Certainly qualitative work in the UK has highlighted the willingness of parents to include other relatives in their childcare 'jigsaw,' and indicating a preference for this type of childcare over formal arrangements (Wheelock and Jones 2002). From the results of my second paper it would appear that having substantial kin contacts does make it easier for families to cope with their first child and thus go on to have an additional child.

Whilst non-household relatives have been provided with a legal priority for childcare in cases of family crisis the use of childcare provided by the extended family has been generally a neglected area of family policy (Hunt 2006; Tan, Buchanan et al. 2010). Currently, in the UK, state expenditure is under intense pressure. Incentives to encourage the use of informal childcare rather than formal childcare could be a cost effective way of reducing the expenditure dedicated to the goal of increasing the labour force participation of females with young children.

It should also be noted that there may be benefits to the relatives who provide such childcare. Certainly Clarke and Roberts (2003) show that 40% of their sample of grandparents wanted greater contact with their grandchildren. Evolutionary theorists have also developed a strong interest in social networks and development. Authors such as (Dunbar 1998; Hrdy 2009) have stressed that the sociality of *Homo sapiens* was a key aspect in the evolution of many of our species' unique features, particularly our cognitive

traits such as intelligence. It is plausible that childcare provided by familiar relatives with a strong emotional attachment to the child may be more beneficial for emotional development than childcare provided by formal institutions. Though whether children cared for by relatives actually benefit from such care remains an open empirical question (Coall and Hertwig 2010).

2.2. Postpartum depression and kin social support

A more specific problem faced in many developed countries is postpartum depression which effects around 13% of mothers (O'Hara and Swain 1996) and has negative consequences for the mother, her partner and her children (Gibson, McKenzie-McHarg et al. 2009). Postpartum depression is correlated with social network support and it has been argued by some evolutionary theorists that such postpartum depression is adaptive response to perceiving having an insufficient support network (Hagen (1999); Watson and Andrews (2002) though see Nettle (2004) for critique). Whilst this thesis does not test the effects of kin on postpartum depression again it can be inferred from the second paper that kin do make the transition to parenthood easier. It is plausible that family policies which encourage contact with close relatives may have a beneficial consequence of reducing levels of postpartum depression.

2.3. Demographic stability

Below replacement fertility has potentially substantially negative macro-level consequences; it will induce population ageing and will ultimate lead to a decline in population size. This could have negative consequences for many areas such as labour supply to pension funding to national security (McDonald and Kippen 2001; Eberstadt 1991; McDonald 2006). The transition from first to second birth has major policy implications as in contemporary Europe the variance in total fertility is often the product of variance in parity progressions after the first child (Frejka 2008). From the results of my second paper it would appear that strong kin contacts seem to offset some of the costs of having children. Therefore governments seeking to increase their fertility rate could do so by adopting policies to strengthen inter-family communications and by providing incentives for relatives to undertake childcare.

I must be remembered that the implications from sections 2.1 and 2.3 link together and there are a whole host of potential linkages and potential feedback mechanisms. As set out by many authors including (McDonald 2000; Engelhardt and Prskawetz 2004; Mishra and Smyth 2010) the relationship between government policy, female labour force participation and fertility is complicated, and there are arguments for a range of causal directions.

3. Future developments: Understanding Society context effect experiment

Both the kin and context effect work could be expanded in a variety of ways. In the conclusion of the final paper I stress the importance of replicating such context effect studies, and this point also applies to the first two papers as well. I have combined my interests in context effects and kin effects, and have developed a proposal to use a kin priming context effect experiment in a nationally representative longitudinal survey. This proposal has been accepted in the Innovation Panel, a subsample of 1,500 households from the UK Household Longitudinal Study (UKHLS - the successor of the BHPS) by the Methodological Advisory Committee of the UKHLS. I have discussed the proposal with leading survey methodologists and it appears to be only the second time that a question ordering experiment has been embedded in a representative social survey. It is the first time one has been included in a large scale survey in the UK and appears to be the first longitudinal measurement of context effects using the same individuals. The UKHLS context effect project will tie together the two different parts of my thesis, as it will use as priming questions the same items on friendship group / emotionally close social networks that I showed predicted actualised fertility in the BHPS. At the aggregate level I predict that priming individuals to think about their close social support network should increase their fertility intentions. It is also possible that the priming may work in the opposite direction as well, whereby making respondents think about their future childbearing stimulates them to pick more relatives within their close social support network, as it is relatives who are more likely to undertake childcare and be ‘pleased’ by the respondent’s childbearing.

4. General conclusions

Human fertility remains puzzling as the number of children that an individual has is influenced by a myriad of factors at both the proximate and ultimate levels. The fundamental purpose of this thesis is to help understanding of childbearing in contemporary Britain by utilising the perspective of Evolutionary Demography. I would argue that it has demonstrated the utility of such a perspective. As set out by Kohler earlier 'unfortunate' developments in the incorporation of evolutionary and social sciences, such as eugenics movement of the 1930s, should not lead to evolutionary theory being 'banned from the toolbox of demographic research' (2001, page 33). There appears to be a trend in demography towards to the reconciliation of the biological and social scientific approaches and this reconciliation was recommended in the 2005 Handbook of Population as one of three major areas for future development (Poston, Baumle et al. 2005). As set out by Casterline to fail to recognize that mortality and fertility are determined in part by biological variables 'requires either extraordinary blindness or exceptional stubbornness' (1995, page 359).

Individual humans are capable of a spectacularly diverse array of behaviours, both positive and negative. Incorporating evolutionary ideas into the social sciences means understanding our species' behaviours in the context of the behaviour of other species. This thesis is limited temporally, spatially and to fertility and fertility preferences. Nevertheless it makes predictions using cross-species evolutionary biological theories and the empirical analysis supports these predictions. It is an example of the utility of an evolutionary perspective in helping to understand our species behaviour in a contemporary complex society.

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