Both Nature and Nurture: Incorporating Genetic, Developmental, Directed Environments, and Social Learning within a Demographic Micro-Simulation Model

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Abstract

Much demographic research is concerned with the estimation of the magnitude of the effect of covariates, such as educational level or socio-economic status, on outcomes such as childbearing or death. Sub-disciplines have emphasised the role of interactions between people in terms of social networks and social learning (Kohler, Behrman and Watkins 2000; Cohen and Syme 1984). A second strand of explanation based originally in genetics and psychology has been concerned with attempts to partition variability of phenotypic characteristics into 'genetic' (or 'nature') and 'environmental' (or 'nurture') components (Plomin et al 2001). Examples of variables include highest educational level achieved or physical measures such as height, which are associated with both genetic and environmental influences, and are also characteristics associated with assortative mating. From a modelling viewpoint, a key factor is how far, and by what mechanisms, these traits are inherited intergenerationally, which forms the focus of this paper

Much of the empirical analysis of 'genetic' and 'environmental' influences has been based on atypical but apparently natural experiments such as comparing non-identical and identical twins, or identical twins separated at birth and brought up separately (implicitly assuming that twins have similar environments in the first case, and that allocation of adoptive parents is random in the second case). Even here, there are problems, since the twins will have nine month of correlated environments in their mother's womb, and the assumption that allocation is random is also questionable (Plomin et al 2001). There is debate about the extent to which models that analyse the contribution of nature and nurture to human behaviour take the covariability between these factors into account, often assuming that they are independent (Capron and Vetta 2001). However, since relatively few children are not brought up by at least one biological parent, for analysis of population trends, it is the *overall* effect, including the covariance, that is important (Murphy and Wang 2002): in some cases, it is likely that this covariance may be the dominant factor (Bowles and Gintis 2001).

A second common assumption in models is that parents are uncorrelated in their characteristics, which is required for many fundamental models of inheritance including the Hardy-Weinberg Law (Cavalli-Sforza and Bodmer, 1971 p 337). Such an assumption is employed either because of lack of data, or because it is required for model tractability, even though evidence suggests that this is rarely if ever the case (e.g. Epstein and Guttman 1984).

A clear-cut distinction between 'genetic' and 'environmental' influences is artificial. For example, the most widely-cited example of a 'purely genetic' disease is Phenylketonuria (PKU),

an ability to metabolise the amino acid phenylalanine, it is treated by a purely environmental means, by restricting the relevant amino acid in the diet. More recently, the importance of developmental factors in a range of outcomes has been recognized: for example, exposure to language at an early age makes learning it much easier than if done later (and of course, many animal studies have shown similar effects experimentally) (Bateson and Martin 1999).

This paper considers the conceptual basis of inherited and acquired factors and their application within a demographic micro simulation model, including the following mechanisms:

1. People adjust their current environment according to their previous cumulative environment experiences, which are also likely to be correlated with the initial endowment of the individual
2. People's environments in successive time periods are positively correlated, and people adjust their social environment in order to form networks with people whose characteristics are positively correlated with their own
3. People's outcomes, such as health or educational status, are influenced by, and in turn, can influence their social networks

In this paper, I consider how to model intergenerational patterns[1] sequentially showing how the means, variances, distributions and inter- and intra-generational correlations vary under a range of alternative models.

- Model 0: Partnership is random, with no intergenerational transmission and no effect of environment.
- Model 1: As 0., but with intergenerational transmission. The forms of models that can exist and distributional forms that can be used are discussed (e.g. the use of uniform, beta, gamma and normal distributions).
- Model 2: As 1., but with assortative partnerships. The ways in which partnership functions are operationalised in closed micro simulation models to produce 'realistic' patterns are considered (Bouffard et al 2001).
- Model 3: as 2., but with random environments, the ways that this can be operationalised are considered, e.g. one or higher dimension random walks.
- Model 4: As 3., but with environments that are correlated with both initial endowment, and with previous experience up to that age.
- Model 5: As 4., but considering how individuals modify the environment of their networks leading to feedback behavioural models (this will only be sketched out).

These models, apart from 5., are based on the SOCSIM kinship micro simulation model originally developed at Berkeley by Professors Wachter and Hammel (Hammel, Mason and Wachter 1990), which has been modified to incorporate the influence. Earlier work has shown that population sizes are very sensitive to intergenerational continuities in fertility (Murphy and Wang 2002), and that this model can incorporate homeostatic demographic feedback

[1] 'Patterns' is a general term that includes all aspects of the phenotype, both 'physical' and 'behavioural', although once more, such distinctions are not clear-cut. For concreteness, such aspect could include relatively uncontentious variables such as height, or contentious ones such as IQ, or the propensity to have children or to dissolve partnerships. In the last two examples, the key distinction is that both run in families, the former is correlated with fitness (reproductive success), but the latter is essentially independent of it.

mechanisms (Murphy 2003). The model is designed to replicate trends in a contemporary Western developed country population over a long period of time.

The formulation is abstract, but it is illustrated by concrete examples where appropriate, and the lack of information to operationalise some of the concepts is discussed. Since the approach depends on the concept of directed environments, this will now be sketched out.

Directed Environments

People shape their environments and they themselves shape the environments of others. The role of social networks on health throughout the life course is recognised as substantial (House, Landis, and Umberson 1988), and that behaviour is determined by social learning as well as via formal educational systems. Demographic research has recognised the role of dynamic processes such as diffusion of ideas rather than demographic process responding mechanistically to changes such as urbanisation in the case of the European Demographic Transition (Coale and Watkins 1986). The role of social learning can lead to counter-intuitive results such as multiple equilibria for fertility (Kohler 2000). At the same time, the role of life course events even in the pre-natal phase is found to have influences up to the oldest ages levels (Barker 1994; Elo and Preston 1992; Kuh and Ben-Shlomo 1997). Other findings suggest that the extent to which we shape out environments may powerful: for example, identical twins who live apart tend to become more rather than less similar in some aspects over their lives (McClearn et al 1997). If environments were random walks, such a finding would be difficult to explain.

An individual's environment[2] at different time points is positively correlated . Thus is uncontentious: many aspects are fixed, such as parents' age at a child's birth, or change relatively slowly for long periods in the life course, such as geographical location, employment type, and social networks remain relatively stable over time. We expect the environment of a person *i* at age *t+n* to be more similar to that of person *i* at age *t*, than an average other person at age *t*. However, changes in environments are less clearly positively associated with previous environment, but they are also likely to be determined in part by previous experiences, and a positive association is plausible. A person who has previous above average income or cognitive ability is likely to remain relatively privileged when changes occur, and these changes will tend to reinforce previous characteristics: those with high cognitive abilities will be morel likely to undertake leisure activities that reinforce such abilities, and, in particular, they are likely to have social networks that mean that their partners will have similar characteristics, and so such traits will be passed on through generations. Such a formulation does not require that such traits be transmitted genetically since environmental factors will also be relevant, but lead to correlations between current environments and earlier ones and parental endowment.

[2] 'Environment' includes aspects such as employment, schooling, family life etc., but it is indexed by a single variate $e_{t,i}$ for person *i* at time *t.* The variance of $e_{t,i}$ is that of the environmental variable included in conventional statistical models.

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