

Symmetry as destiny – taking a balanced view of IQ

Steve Blinkhorn

Genetic vulnerability during development may be responsible for environmental effects on intelligence. Taken with a study showing that the heritability of IQ does not change with age, could these results mean that nature and nurture are no longer in opposition?

The study of human intelligence has always had its feet in biology and its head in the clouds — the recent encounter between Gary Kasparov and Deeper Blue showed what can be achieved in confronting human intelligence with methods that have no plausible claim to mimic its cognitive processes. Two studies at the other end of the spectrum now serve as a reminder that intelligence operates on a substrate of wetware, not silicon.

In the 6 June issue of *Science*, McClearn *et al.*¹ described a study of octogenarian Swedish twins, in which they found that the heritability of psychometric intelligence remains much the same in old age as in youth. And in this week's *Proceedings of the Royal Society*, Furlow *et al.*² show that there is a modest, but replicated, association between IQ and asymmetry in bilateral human physical traits. These observations lead to nicely paradoxical conclusions, relating environmental influences to the genetic basis of differences in IQ.

Research into heritability and the biological correlates of measured intelligence tends, unfortunately, to descend into a kind of cognitive Calvinism. Heritability estimates take on the mantle of constants of nature, social pessimism holds sway, and all concerned resign themselves to predestination due to unknown genes. Because there has long been evidence for the heritability of IQ, the idea took hold that there must, therefore, be genes for intelligence — just as theories now circulating suggest that there may be genes for homosexuality. Of course, ideas about the heritability of intelligence pre-date the notion of a gene, and they go back certainly as far as Francis Galton.

McClearn *et al.*¹ have found that estimates of the heritability of IQ amongst octogenarians are of much the same magnitude as estimates from younger age-groups (of the order of 0.60). This result is surprising only because common sense suggests that, with the passage of time, the effects of experience will become increasingly important in determining cognitive abilities. So, the influence

of heredity should become proportionately less. But if the Swedish study is to be believed, environmental influences on IQ have their effects early. This is hardly controversial stuff and, indeed, potential factors (such as atmospheric lead, maternal nutrition and fetal alcohol syndrome), which indicate a biological rather than a strictly psychological influence, will always focus on the earliest stages of life.

Unfortunately, having relatively stable estimates of the heritability of IQ advances our knowledge rather little. Because we have no sensible systems by which to measure either the variability of environments or the variability of genetic influences, we are left with a ratio of two unknowns. The only conclusions that are left to be drawn are socio-political — heritability of IQ is so great (or small) that educational or social programmes will have insignificant (or enormous) effects.

The problem is, opinion is split three ways as to how to handle the raw observation that observed intellectual capacity varies widely. Those with their heads in the clouds — artificial-intelligence researchers and constructors of psychometric tests (sky pilots for short) — mark their progress by results. Intelligence is about handling difficult tasks successfully, and doing well when you started off not knowing what to do. These sky pilots aim to keep at least two steps ahead of those who find algorithmic solutions to cognitive tasks, and they provide measures which act as criterion variables in studies of heritability and the biological correlates of intelligence.

The second group — the biological determinists or chiropracists (podiatrists if you must) — have their feet firmly planted in biology. They, at worst, suppose that the most we can do is to observe biological determinism, and then look for simple models to explain why variation in intelligence reflects biological variation. Such models include differences in neural efficiency, speed of conduction, or error rates. But whatever you do, don't confuse them by pointing out

the possibility of mental processes that are not strictly reducible to brain processes.

In between are the colonizers from cognitive psychology, who betray their insecurity by adopting the term 'cognitive scientists'. They propose to explain away — rather than to explain — the brute facts of variability in cognitive capacity. They supply the algorithms for solving problems which keep the sky pilots on their toes. For about 25 years they have been promising to account for variability in IQ in terms of cognitive-processing models. (The first positive results are still eagerly awaited.)

Results, processes, substratum — the three foci of interest that divide those who study human intelligence. But somewhere in there is a mind-brain barrier, a conceptual and philosophical divide that stands in the way of progress. The artificial-intelligence and psychometric researchers may set problems and recognize the results as showing the external hallmarks of intelligence, but they have little to say about how to make people more intelligent, or overcome handicaps to achieve their potential. Cognitive scientists have shown how styles of problem that were once thought to require poorly understood human capacities can be reduced to computational algorithms. Yet they have contributed essentially nothing to our knowledge of how some people, when presented with a mass of confusing data, can clearly see the underlying structure of a new problem, whereas others cannot. And the biological determinists can point to over 100 years of consistent findings, but not a lot of hope on offer.

This is where the paper by Furlow *et al.*² seems to break new ground. They have studied fluctuating asymmetry — an asymmetry of usually symmetrical bilateral traits, which occurs as a result of biological stress during development. Fluctuating asymmetry is assessed by an index of variability in the dimensions of feet, fingers, wrists, elbows and ears. The authors claim that fluctuating asymmetry correlates between 0.20 and 0.25 with psychometric intelligence. Moreover, this is probably an underestimate — values of 0.30 to 0.35 might be expected in experiments using a better IQ test criterion and subjects from the full range of IQ, rather than the undergraduates from the University of New Mexico who were studied by Furlow and colleagues.

What form of stress might cause fluctuating asymmetry, and in what sort of sub-optimal development might it manifest itself? Furlow *et al.* cover all possibilities, including effects on any level of structure in the central nervous system. This is anything but satisfactory from a theoretical point of view, but quite in keeping with their report, which is essentially a data paper.

The authors propose that people are differentially susceptible to environmental

influences on their IQ, because of their genetic endowment. They believe that these susceptibilities are likely to have their effects early in life (for instance, prenatally). That is, they suppose that there is a real, common, causal link between bodily asymmetry and lowered IQ. Indeed, they are prepared to estimate that anything between 17 and 50 per cent of the variability in IQ is attributable to such causes. If the upper estimate proves to be accurate and replicable, then fluctuating asymmetry could account for almost all heritable sources of variability in IQ. But it is hard to believe that such a long-standing conundrum as the relative contributions of nature and nurture to IQ could be turned into no more than a neat paradox — nurture's influence depends on genetic predisposition — in one go.

The really neat thing is that Furlow *et al.* have used a method that is potentially within the reach of any psychology undergraduate — a method, in fact, that was almost within the reach of Francis Galton — requiring no more than callipers and the product-

moment correlation coefficient. They have a couple of tentative theoretical accounts as to why they should have got the results they report. These include structural developmental imperfections, leading to less efficient neural processing, and a differential use of energy budgets in people who have suffered varying degrees of developmental stress. But neither of these is more than an indicative hypothesis for the time being.

Expect many attempts at replication — low-life demonstrations that blacks/half-breeds/less-favoured races suffer more from fluctuating asymmetry than white, middle-class golden youth. Also expect, in general, a failure to recognize that Furlow and his colleagues may just have glimpsed a way of reconciling the long-standing antagonism between chirpodists and sky pilots. □

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1. McClearn, G. E. *et al.* *Science* **276**, 1560–1563 (1997).
2. Furlow, F. B., Armijo-Prewitt, T., Gangestad, S. W. & Thornhill, R. *Proc. R. Soc. Lond. B* **264**, 823–830 (1997).

Galaxy evolution

The end of the beginnings

Roberto Abraham

An eerie feeling has overtaken recent gatherings of observational and theoretical cosmologists* — a sense of impending (if not quite actual) consensus. A broad outline of the processes by which galaxies form and evolve, in rough agreement with the predictions of theory, seems to have emerged from a number of recent galaxy surveys^{1–4}.

We classify galaxies by their distribution of stars, so galaxy evolution can be quantified by changes in star-formation rates. These can be measured by looking back to galaxies with increasing redshifts (thus further from us, and earlier in the Universe; Fig. 1), at different wavelengths, to see how the average brightness and spectrum change. In the past two years the accessible redshift range has expanded up to $z < 4$. This is remarkable progress: until recently, studies of 'normal'-galaxy populations were restricted to redshifts $z < 1$. However, the discovery⁴ that the so-called 'Lyman dropout' galaxies (which appear anomalously faint through blue filters because a prominent ultraviolet spectral break has been redshifted into optical wavelengths) are at redshifts greater than two, has increased enormously the number of known high-redshift galaxies. Around 80–90% of the total age of the Universe is now being



Figure 1 Back in time — the Hubble Deep Field, of which this is a view, has helped to revolutionize understanding of the Universe at high redshift.

probed by galaxy surveys. That is comparable to the fraction sampled by the relatively rare quasars and radio galaxies.

The current observational picture is summarized by the star-formation history curve (Fig. 2) (P. Madau, Space Telescope Sci. Inst.). By adding together the luminosity contributed by all the galaxies in a series of redshift intervals, this curve maps out a precipitous rise and fall in the production of stars and 'metals' (elements heavier than helium) in a given volume of the Universe as a function of redshift⁵.

The volume-averaged star-formation rate over such a large fraction of the total age

of the Universe is a powerful clue to the timescales over which galaxies form. The most remarkable aspect of Fig. 2 is the rapid decline at high redshift: this indicates that current surveys, by probing out to redshifts near 5, are now seeing almost all of the galactic history of the Universe. The epoch of peak star formation is around $z=1.5$.

The curve supports a hierarchical picture of galaxy formation. Hierarchical models "treat galaxy formation as a process, not an event" (S. White, Max Planck Inst. Astrophys.): the idea is that small, amorphous proto-galaxies form first, eventually settling into disk galaxies such as spirals, which can then also merge to form ellipticals. Rival theories suggest that giant galaxies form via the collapse of a single massive gas cloud at high redshift, with the nature of this initial collapse, rather than subsequent galaxy mergers, determining the form of the galaxy.

Hierarchical models predict star-formation histories that agree at least qualitatively with those in Fig. 2. There are a few theoretical embarrassments which refuse to disappear from the simulations — such as egregiously small galactic disks with low angular momenta (G. Efstathiou, Univ. Oxford; M. Steinmetz, Steward Obs.) — but even so there is considerable confidence in these models, and so much of the theoretical focus is now on the details of the different galaxy types^{6–8} that contribute light at different redshifts. For example, is the light at the highest redshifts coming from proto-elliptical galaxies (M. Giavalisco, Carnegie Obs.), or do ellipticals form continuously over a range of redshifts (G. Kauffmann, Max Planck Inst. Astrophys.)?

But there is one unresolved question about the overall star-formation rate. Some of it must be missing from Fig. 2 because of dust contamination. Dust scatters and absorbs light most strongly at short wavelengths, and, because of the expansion of the Universe and the corresponding redshift, the more distant the galaxy, the shorter was the original wavelength of the light we see. So it may be that distant, actively star-forming but very dusty 'starburst' galaxies contribute much of the total brightness of the Universe but are nonetheless missing from optical surveys. Sensitive infrared surveys will be able to detect such systems, if they exist.

The question is: how much light are we missing? Nearby starburst galaxies appear to have spectra that curve upwards from the ultraviolet to the infrared, and if dust-enshrouded starbursts in the distant Universe (at $z > 1$) have similar properties, they could contribute more than ten times as much energy as is accounted for in the star-formation history curve (G. Meurer and T. Heckman, Johns Hopkins). That agrees with a preliminary analysis of images obtained by the Infrared Space Observatory satellite,

*The Hubble Deep Field: Space Telescope Science Institute May Symposium, Johns Hopkins University, Baltimore, USA, 6–9 May 1997; and The Ultraviolet Universe at Low and High Redshift: Probing the Progress of Galaxy Formation, College Park, Maryland, USA, 2–4 May 1997.