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Harden, Kathryn Paige. 2021. *The Genetic Lottery: Why DNA Matters for Social Equality*
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Open a behavioral genetics textbook, and the table of contents will look something like this: first some background and history—animal breeding, Mendel's laws, and so on; move onto biological substrates such as DNA, chromosomes, and meiosis; introduce methodological tools such as pedigree analysis and twin studies; and identify statistical constructs and methods such as heritability, genome-wide association studies (GWAS) and polygenic scores. Topics like gene-environment interplay (i.e., G×E interaction and correlation) are typically left for later and introduced as additional modifying factors. Kathryn Paige Harden's new book *The Genetic Lottery: Why DNA Matters for Social Equality* is a concise introduction to the field of behavioral genetics, but it is notable for its reshuffling of the conventional order. From the beginning, we are given an up-to-date understanding of gene-environment interplay and contextual modulation of genetic effects. The role of the environment and context are presented as inextricable elements of a science of human genetics, rather than as additional moderators. Harden's message is clear almost to the point of painful repetition: we can learn about protein synthesis, Punnett squares, and pleiotropy, but these units of knowledge are splintered from any insight about human behavior and psychology unless folded into the socio-economic, institutional, and historical fabric of the world we live in. The behavioral genetics Harden offers is an equal reconciliation of the biological and social sciences, in which data and methods from both traditions are smoothly integrated to help us understand difficult problems that arise at the intersection of both.

But Harden is hardly heterodox. The ideas described in *The Genetic Lottery* are well known among behavioral geneticists, and the described empirical findings and their interpretations are uncontroversial within the field. The science has come far in recent decades, illuminating the role of feedback loops between genes and environments and the difficulty of generalizing findings across societies—this is by no means the first popular treatment of these issues. Nonetheless, Harden's synthesis of facts and findings into a coherent and communicable framework that does not shy away from controversial topics is masterful. For example, *The Genetic Lottery* contrasts noticeably with her esteemed colleague Robert Plomin's *Blueprint: How DNA Makes Us Who We Are* (2018). Plomin's book presents largely the same science but with a considerably more optimistic view on the utility of genetic data in relative isolation from its socio-economic context. Despite a largely shared understanding of empirical findings and technical approaches, Harden and Plomin paint divergent pictures about what all this means for understanding ourselves, our societies, and the paths forward. Harden's vision will appeal most to those who seek science-based solutions to social problems but are turned off by the perceived moral consequences of behavioral genetics. As a result, the book may widen the Overton window on what is acceptable public discourse about behavioral genetics without provoking denial of the underlying science. But in other respects, the book

reproduces a set of hidden assumptions and conceptual limitations that are entrenched in the behavioral genetic literature. Fields, after all, can often be defined by what they consider signal and what they consider noise.

Harden goes further than most in drawing attention to the dynamic modulation of genetic effects by social factors such as wealth inequality, educational reform, and technological innovation. It has long been acknowledged that G×E interactions and correlations complicate the interpretation of genetic effects, while also demonstrating how environments can differentially channel phenotypic development. If relevant environmental variation can be generated by events within industrial, economic, educational, and legal spheres as Harden describes, then the human activity-dependent character of genetic effects becomes clear. Many of these events, such as the changing of a curriculum, occur incidentally and only happen to leave their trace upon behavioral genetic estimates. But their effects hint at the possibility of deliberate design. This dynamic character of real-world G×E interplay makes it plain that we possess the institutional means to steer aspects of the socio-economic environment toward collectively desired ends. This sense of agency seemingly upends the status of genetic knowledge within public policy, from a nuisance that is best ignored—if there's nothing we can do about genes, why focus on them—to a challenging yet promising instrument in the pursuit of social progress. It is thus no surprise that *The Genetic Lottery* is rife with references to policy implications, confidence in the practicability of the approach, and overall optimism about both social change and change in popular perceptions about the moral consequences of genetic science. Its overview of socially contingent G×E interplay naturally evokes a programmatic vision for a constructive role of genetics in contemporary and near-future societies. However one feels about the political will that animates the discourse, or about the practical feasibility of such a program, there is certainly a rhetorical coherence in the author's dovetailing of scientific theory and (envisioned) political practice favoring her openly admitted political positions.

The foundation of Harden's program is thus the dynamic and regulable character of the human environment. But for a narrative that relies so much on the idea of a changing and changeable environment, it is strikingly stereotyped about the way in which environments actually change. In the book, environmental complexity can be captured by a small taxonomy, consisting of something like *gradients*, *groups*, and *discontinuities*. Income inequality is a gradient, albeit a heavily skewed one. Disparate opportunities across races or social classes are demarcated in groups. When one educational policy is replaced by a better or worse alternative, this is often a noteworthy discontinuity. This taxonomy mirrors the structuring of genes: gradients over latitude, groupings by islands, discontinuities by disrupted food chains.

In genetics, the idea of a *reaction norm* refers to variation in phenotypic expression that can emerge when individuals who share a common genotype are exposed to a range of environments. Reaction norms capture G×E interactions and are most commonly represented as a curve that maps the level of some environmental variable onto phenotypic variation of some trait. For many decades, a common critique against the field of behavioral genetics was that environmental variation in humans is typically either too large or too unknowable to support the validity of genetic effects like heritability. Heritability is a valid measure when environmental variation is systematically controlled, as it often is for livestock, but when reaction norms are not flat and especially when they are nonlinear, heritability becomes a less useful statistic. Genetic methods that are effective for nonhuman species can be ineffective for humans due to the complexity of our environments. *The Genetic Lottery* is both a natural development and an updated iteration of this line of reasoning, but what the author

brings in addition to this familiar argument is the systematic observation that environmental complexity is often begat by social and institutional forces, and that these forces can be applied for the betterment of society. But this approach clearly hinges upon a deep understanding of environmental complexity and change. An insufficient understanding of the structure and dynamics of human environments is a stumbling block for effective action, and this is where Harden and indeed the field of behavioral genetics could go further.

In a new *Behavioral and Brain Sciences* target article on the "cultural evolution of genetic heritability," we present a dual inheritance framework that integrates cultural evolution and behavioral genetics (Uchiyama, Spicer, and Muthukrishna 2021). Cultural evolution (Cavalli-Sforza and Feldman 1981; Boyd and Richerson 1985; Richerson and Boyd 2005; Chudek, Muthukrishna, and Henrich 2015; Henrich 2016) is emerging as a theory of human behavior (Muthukrishna and Henrich 2019). It extends models derived from population genetics into the social sphere through an interdisciplinary array of empirical approaches and mathematical formalizations that capture the evolution of culture and environments. The cultural evolutionary behavioral genetics that we propose offers the methods and statistics needed to fulfil Harden's vision. This framework is grounded in a richer, more accurate view of the environment. The environment is seen not as an inert stage or unpredictable backdrop on which genes play out, but as a culturally evolving co-contributor to human behavior that is at least equal to and arguably more powerful than genes.

Such an approach walks the middle path between environments being too complex to understand—thereby undermining the utility of behavioral genetics—and a simple reaction norm approach that applies non-human genetics to humans whose phenotypes are deeply shaped by both culture and genes. Behavioral geneticists will find recognizable complexities and solutions in cultural evolution. For example, we know that populations are in some sense not real, weakening a clear division between and within populations (Muthukrishna et al. 2020). Distributions of genotypes are rarely described as discrete groups or even simple gradients. Individuals occupy a position within a high-dimensional, changing genotypic space. Populations are clusters within this space—detectable, but the exact structure of which is shaped by researcher decisions (Rosenberg 2002). Mating patterns, competition for resources, physical geography, reproductive rate, developmental plasticity, and the size of the gene pool are all factors that influence the dynamics of genetic transmission. This richness in population genetic models is starkly juxtaposed against relatively simple models of the environment. To understand humans, whose environments have been shaped by thousands of years of cumulative cultural evolution, requires models of environmental variation that are more sophisticated than those Harden deploys. Indeed, models of the environment need to embody the same level of complexity that are captured by population genetic models, instead of the reduced environmental variation represented by a reaction norm. Cultural evolution offers the necessary tools.

Human environments consist of not only physical infrastructure, but also technology, social norms, group organization, institutions, and accumulated knowledge, all of which influence phenotypic development. There is remarkable variation on these dimensions even within societies, and immeasurably more between societies (Henrich, Heine, and Norenzayan 2010; Apicella, Norenzayan, and Henrich 2020; Muthukrishna et al. 2020). But we need not be overwhelmed by this complexity. There are well studied and well understood rules that shape human environments, just as there are well studied and well understood rules that shape genomes. Without the perspective of cultural evolution, the world

created by humans seems complex and chaotic, just as the biological world seemed complex and chaotic prior to an understanding of genetic evolution. But it need not be that way. *The Genetic Lottery* is a valuable contribution moving us toward such an integration.

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