ARTICLE IN PRESS
INTELL-00801; No of Pages 14
Intelligence xxx (2013) xxx–xxx
Contents lists available at SciVerse ScienceDirect
Intelligence
journal homepage:

# Nature, nurture, and expertise☆

Robert Plomin *, Nicholas G. Shakeshaft, Andrew McMillan, Maciej Trzaskowski

*King's College London, MRC Social, Genetic & Developmental Psychiatry Centre, Institute of Psychiatry, London, SE5 8AF, United Kingdom*

ARTICLE INFO

*Article history:*
Received 16 April 2013
Received in revised form 11 June 2013
Accepted 13 June 2013
Available online xxxx

*Keywords:*
Twins
Reading
Genotype–environment interaction and correlation
Non-shared environment
Liability-threshold

ABSTRACT

Rather than investigating the extent to which training can improve performance under experimental conditions ('what could be'), we ask about the origins of expertise as it exists in the world ('what is'). We used the twin method to investigate the genetic and environmental origins of exceptional performance in reading, a skill that is a major focus of educational training in the early school years. Selecting reading experts as the top 5% from a sample of 10,000 12-year-old twins assessed on a battery of reading tests, three findings stand out. First, we found that genetic factors account for more than half of the difference in performance between expert and normal readers. Second, our results suggest that reading expertise is the quantitative extreme of the same genetic and environmental factors that affect reading performance for normal readers. Third, growing up in the same family and attending the same schools account for less than a fifth of the difference between expert and normal readers. We discuss implications and interpretations ('what is inherited is DNA sequence variation'; 'the abnormal is normal'). Finally, although there is no necessary relationship between 'what is' and 'what could be', the most far-reaching issues about the acquisition of expertise lie at the interface between them ('the nature of nurture: from a passive model of imposed environments to an active model of shaped experience').


## 1. Introduction

The relative influence of nature and nurture has been central to research on expertise since Francis Galton's (1865) two-article series on hereditary genius, which he expanded into the first book in the field of behavioral genetics, *Hereditary genius: an inquiry into its laws and consequences* (Galton, 1869). Using mere reputation as an index, Galton suggested that ability – brains as well as brawn – runs in families. He greatly overinterpreted his results to conclude that genius is hereditary and that "ability will out" regardless of environment.

During the 150 years since Galton's first papers, the pendulum has swung back and forth between nature and nurture in the behavioral sciences. For the first fifty years, the influence of Galton and his cousin, Charles Darwin, pushed the pendulum towards nature. In the 1920s, John Watson's behaviorism, which led to environmentalism, began to push the pendulum towards nurture. This swing was accelerated by the eugenic horrors of Nazi Germany in the 1930s and 1940s. After World War II, psychology was dominated by learning theory and an environmentalism that assumed that we are what we learn. However, by the 1960s and 1970s, the pendulum began to swing back towards a more balanced view that recognized the importance of nature as well as nurture. With the breath-taking advances in genetics in recent years, there is some danger now that the pendulum may be swinging too far back to nature (Plomin, 2013).

In all areas of the behavioral sciences, genetic influence has been shown to account for substantial variance, but this


* Corresponding author at: King's College London, DeCrespigny Park, Denmark Hill, London, SE5 8AF, United Kingdom. Tel.: +44 20 7848 0985; fax: +44 20 7848 0092.
*E-mail address:* robert.plomin@kcl.ac.uk (R. Plomin).

0160-2896/$ – see front matter © 2013 The Authors. Published by Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.intell.2013.06.008

Please cite this article as: Plomin, R., et al., Nature, nurture, and expertise, *Intelligence* (2013), http://dx.doi.org/10.1016/j.intell.2013.06.008

same research provides strong evidence for the importance of environment as well. Heritability, which is an effect size index of the proportion of phenotypic variance that is accounted for by genetic variance, is typically between 30 and 60% across psychological traits, which means that 40–70% of the variance is *not* genetic in origin (Plomin, DeFries, Knopik, & Neiderhiser, 2013). The issue is not nature versus nurture, but rather nature *and* nurture because both are important, which suggests that the way forward is to develop strategies that bring nature and nurture together to help us understand the development of complex traits (Rutter, Moffitt, & Caspi, 2006). There are signs that the nature–nurture battles are over. For example, over 90% of parents and teachers of young children believe that nature is as important as nurture in the development of a wide range of behavioral traits, including intelligence, learning disabilities, personality and mental illness (Walker & Plomin, 2005).

In this context, the domain of expertise might seem atavistic, stuck in the nature versus nurture era. However, this view is more apparent than real because the extreme environmentalist position has been promoted by very few people (Ericsson, 2007; Howe, Davidson, & Sloboda, 1998); in the other corner, we can find no one who espouses an extreme hereditarian position. If a survey of opinions about the relative importance of nature and nurture in expertise were conducted in academia like the one mentioned above for parents and teachers, we predict that academics in all disciplines would also overwhelmingly accept the importance of nature as well as nurture. (See Tucker & Collins, 2012, in relation to sporting success.) In our opinion, this faux debate about nature *versus* nurture in the domain of expertise is a distraction that obscures many interesting empirical questions about the origins of expertise.

In this paper, we consider expertise as exceptional performance (Simonton, 2011), ignoring semantic and etymological issues about words such as 'talent' and 'genius'. People who excel can of course be found in any domain of performance, such as music, athletics, games, and cognitive performance. The topic of this special issue is the acquisition of expertise, which we interpret as asking why some people become experts and others do not. It is important to understand the origins of expertise as it exists in the real world of sports, arts and skills. We refer to the origins of such real-world expertise as 'what is' in order to contrast this approach to much research on the acquisition of expertise that asks a different question about 'what could be' — investigating the extent to which expertise can be acquired by intensive training and practice. The critical point is this: There is no necessary connection between 'what is' and 'what could be'. That is, even if the difference between experts' performance and the performance of the rest of the population were due solely to genetic differences (what is), a new environmental intervention such as a new training regime could still greatly improve performance (what could be). For example, although obesity is highly heritable, if people stop eating they will lose weight; moreover, a novel environmental intervention such as bariatric surgery can dramatically reduce extreme obesity (Dixon, Straznicky, Lambert, Schlaich, & Lambert, 2011). Showing that diets and other interventions can make a difference (what could be) tells us nothing about the genetic and environmental origins of obesity as it exists in the world (what is). In the same way, finding that training improves performance (what could be) tells us nothing about the genetic and environmental etiology of existing performance differences in the population (what is). Although there is no necessary relationship between 'what is' and 'what could be', some of the most far-reaching questions about the acquisition of expertise lie at the interface between 'what is' and 'what could be', a topic to which we will return in the Discussion.

In relation to the 'what is' question, it is a reasonable first step to investigate the extent to which genetic differences contribute to the origins of individual differences in performance because the influence of genetics on individual differences is ubiquitous (Plomin et al., 2013). Genetic research ascribes observed (phenotypic) differences in performance to genetic and environmental components of variance. The proportion of phenotypic variance that can be attributed to genetic differences between individuals is called heritability. Specifically, heritability is a descriptive statistic that describes the average extent to which genetic differences (i.e., differences in DNA sequence) between individuals account for phenotypic differences on a particular measure in a particular sample with its particular mix of genetic and environmental influences at a particular developmental age and secular time (Plomin et al., 2013). In other words, heritability describes 'what is' in a particular sample; it does not connote innateness or immutability. Nor does it indicate the mechanisms by which DNA differences affect individual differences in performance. By itself, DNA cannot do anything — it requires an environment inside and outside the body to have its effects. Access to experience and practice is one of the many pathways between genes and behavior. However, the 'what is' question is the extent to which differences in such experiences as parenting and practice can account for differences in performance between individuals when controlling for DNA differences between them. Genetically sensitive designs are required to disentangle cause from effect in correlations between experiences and performance.

Even if one believed that expertise is solely due to training and that genetic differences play no role, it would nonetheless be useful to conduct genetic research because it can tell us something important about the source of environmental influence: The extent to which the origins of expertise lie in the family environment. We know that expertise in many domains runs in families but it could do so for reasons of nature or nurture. By controlling for genetic influence, genetically sensitive designs can disentangle nurture from nature. This type of nurture that makes two children growing up in the same family is called shared environmental effects. The surprise from research using genetically sensitive designs in many domains is that shared environmental effects are so small (Plomin, 2011). The environment is important, but the salient environmental effects are not shared by two children growing up in the same family, referred to as nonshared environmental effects. It should be noted that this distinction refers to environmental *effects* on phenotypes, not environmental *events* per se. For example, parental divorce is an environmental event shared by children in the family but divorce could have different effects on the children's adjustment.

In order to provide a concrete example of genetic research on the acquisition of expertise, we investigate reading 'experts' — children with exceptional performance on a battery of reading tests such as fluency and comprehension. For the journal *Intelligence*, it might seem odd not to choose as an example exceptional performance on tests of intelligence. We chose reading performance as our example rather than intelligence

Please cite this article as: Plomin, R., et al., Nature, nurture, and expertise, *Intelligence* (2013), http://dx.doi.org/10.1016/j.intell.2013.06.008