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Nature Loads the Gun, the Environment Pulls the Trigger: The Interactive Nature of Evolutionary Psychology

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Abstract

Misconceptions concerning the relationship between genes and behaviour are widespread. Such misconceptions include the notion that evolutionary biologists and psychologists subscribe to genetic determinism. In contrast to this view, much progress has been made in elucidating the interactive nature of genes and environment. In particular behavioural epigeneticists have outlined the role of environmental experiences which allow for the activation of specific genes during development. The knock-on effects of such experiences interacting with the genes an individual inherits helps to explain why personality differences between people occur even when they share most or even all of their genes. The interactive relationship between genes and environment occurs over three time periods: during current brain activity, during development of the individual and during a populations' evolutionary history.

Keywords: Human Genome Project; Nature-nurture debate; Evolutionary psychology; Behavioural epigenetics

Introduction

At the end of the twentieth century, it was widely assumed that the human genome contained around 100,000 genes. Since the advent of the Human Genome Project [1], however, it is now known that this figure is a mere 20,300 or around a fifth of what was expected. When this figure was revealed in February of 2001 many national newspapers ran stories concluding that, given how few genes we really have, they are clearly far less important than the environment in determining human behaviour. Serious broadsheets from the UK Observer to the New York Times all took this line of reasoning that there simply are too few genes in our genome to be as important in the development of human nature as environmental input.

This media response highlights the muddy thinking that surrounds the so called 'nature-nurture' debate. There are at least three major flaws with the line of reasoning adopted by these newspapers. In correcting these we may gain some insight into why, if we are to understand the human condition, we cannot ignore the importance of genes. In examining the gene-environment relationship our intention is to demonstrate that, rather than 'nature verses nurture', a more accurate metaphor is 'nature loads the gun, and the environment pulls the trigger'.

The first flaw in the 'fewer genes than we anticipated' argument is that you can produce enormous complexity from very few instructions. Imagine, for example, that the HGP had determined that we had a mere 35 genes, each of which came in two different varieties (alleles). The various combinations which that number could produce in code would be sufficient for each person on Earth to be unique [2]. Additionally, however, we need to bear in mind that some genes act as 'controller genes' which means they switch on and off various other genes in sequence. Factoring this in, in terms of creating the proteins necessary to create a human, then just 10 of these genes switching each of the other 25 on and off in various complex sequences would be sufficient to produce all of the requisite number of proteins to build a human. This means that, rather than there being too few genes for their role to be important in influencing human behaviour, there is an enormous amount of redundancy in the system. The second flaw is to assume that a reduction in one side of the nature-nurture relationship increases the importance of the other side. The environment cannot act on a brain unless that brain has adapted to react to environmental input. And adapted, of course means that gene combinations have been selected over a geological time frame to allow ancestral humans to meet environmental challenges successfully (see later). In fact, we should not even consider nature and nurture as opposing explanations–environmental input is required at every stage of human development in order for genes to affect behaviour–from conception through to demise (Box 1). Third, it is now known that environmental input can literally switch on or off specific genes. The field that deals with the knock-on effects of environmental input on gene activation (or inactivation) is called epigenetics (see Box 3). The advent of behavioural epigenetics means that, while the environment plays an important role in influencing behaviour, it often does so by altering which genes are activated. We simply cannot remove our genes from the equation.

Box 1: Nature loads the gun and the environment misfires it – the case of Foetal Alcohol Spectrum Disorder

A rather unfortunate example of how nature loads the gun, and the environment pulls the trigger is Foetal Alcohol Spectrum Disorder (FASD, previously known as Foetal Alcohol Syndrome). FASD is a condition where, due to alcohol intake by the mother during pregnancy, children show serious, irreversible cognitive and behavioural deficits. IQ is reduced considerably, and individuals have strange facial features (wide spaced eyes, a small, upturned nose and small head). As a spectrum disorder, FASD varies in its severity from one individual to another. This variation is, in part, due to differences in the amount and timing of alcohol consumption but also, it is now known, to arise from genetic differences between sufferers. Recent research suggests that genetic variation between how well individuals are able to break down alcohol (both in mother and baby) is an important contributing factor in the level of severity of the condition [3]. Put simply, due to genetic differences between them, some foetuses are better able to cope with alcohol stress than others. So, what used to be thought of as simply a product of input from 'nurture' (alcohol) is now known to involve input from 'nature' (genes). This demonstrates how much of the story we miss out on if we ignore the genetic or nurture part of the equation in what is often perceived as a purely environmentally caused condition.

Darwin's Distant Future – The Evolution of Evolutionary Psychology

The notion of an evolutionary psychology can be traced back directly to Darwin [4], who in The Origin of Species suggested that:

"In the distant future I see open fields for more important researches. Psychology will be based on a new foundation, that of the necessary acquirement of each mental power and capacity by gradation. Light will be thrown on the origin of man and his history".

(Note that 'the necessary acquirement of each mental power and capacity by gradation' is long hand for 'evolved' – Darwin was a great, but somewhat long-winded, writer).

We can see quite clearly that Darwin saw his theory of evolution by natural selection as radically altering the direction that psychology was to take ('a new foundation' is more than a minor tweak). Interestingly he also notes that this will be in 'the distant future'–a prediction that proved to be correct. Whilst there were a number of attempts to bring evolutionary theory to bear on psychology since 1859, it is only since the 1990s – Darwin's distant future – that a truly evolutionary psychology has emerged. In 1992, Jerome Barkow, et al. [5] published The Adapted Mind: Evolutionary Psychology and the Generation of Culture. This multi-authored text laid out the ground rules for evolutionary psychology and in so doing proved to be the clarion call for the development of a new form of psychology that Darwin had originally envisaged [6].

Evolutionary psychology is based on the notion that the type of mind we have developed today arose during the evolution of our species to solve recurrent adaptive cognitive and social challenges [7]. Whereas earlier attempts to integrate evolutionary theory into psychology were based on the notion that our behaviour has evolved to help us boost our 'inclusive fitness' (that is pass on as many of our genes as possible) evolutionary psychologists focus on cognitive and emotional adaptations rather than overt behaviour. This means that many of our current internal states and overt responses do not necessarily boost our inclusive fitness, but rather these would have been likely to have done so during our ancient past. This means that there may be a mismatch between many of our current challenges and those that our minds were adapted to deal with. And this, in turn, may help to explain why we are prone to so many mental health problems today. When you consider that during more than 99% of our species' evolutionary past, we lived in small close-knit forager units on the African savannah, then it is not surprising that living in large impersonal cities can lead to depression and anxiety. In Barkow, et al. [5] words we each have a stone-age brain living in a computer-age world. The human brain, as in all species, is, of course, guided in its development by the successful gene combinations that arose through natural selection (see below).

Evolutionary Psychology Presents an Interactive View of Human Behaviour

This view of life has not been without its critics. Evolutionary psychology is regularly portrayed as promoting genetic determinism. That is that our behaviour is encoded in our genes with little or no room for environmental input. Feminist scholars, in particular, frequently portray evolutionary psychology as presenting a genetic deterministic view of sex/gender differences:

"Another concern is the claim that genders differences have evolved over time, which implies that gender differences, are inevitable and unchangeable" [8].

"[Evolutionary psychology] contends that women's and men's brains have evolved in different ways that furnish modern humans with "hard-wired" gender differences..." [9].

As we saw above such views are misplaced as evolutionary psychologists repeatedly present an interactive view of biological and environmental factors (Box 2).

Box 2: Genetic and physiological determinism – components of biological determinism

Genetic determinism is often referred to as biological determinism. In textbooks the two terms are often used as interchangeable. We should realise, however, that the two terms are not perfect synonyms. Technically genetic determinism is one component of biological determinism. As we have seen genetic determinism is the view that genes code for behaviour. Another component of biological determinism is physiological determinism. That is, the notion that physiological systems including hormones such as testosterone control behaviour (see below). Because physiological systems are, in part, genetically endowed, genetic and physiological determinism are closely related. But, because physiological systems such as hormones can be influenced by the environment there is no simple one-to-one relationship between genes and hormones. In summary genetic and physiological determinism are components of biological determinism.

Testosterone and Intergroup Aggression-An Interactionist Perspective

Most people have heard of the 'male hormone' testosterone, and many will be aware of an apparent relationship between this hormone and aggressive behaviour in men. It is commonly assumed that males who have higher levels of testosterone are more likely to resort to intergroup aggression and that the amount of this hormone a man has is determined by his genetic code. In fact, both of these assumptions are gross simplifications of a complex biology-environment interaction. In order to understand the relationship between testosterone and behaviour we need to realize that steroid sex hormones act in two complementary ways – 'organizational' and 'activational'. In the case of the organizational effect testosterone and other related male hormones (known collectively as androgens) organize neural pathways in the brain during development (including in the hypothalamus, see later). According to biological psychologists this causes the brain of males to become 'masculinised' prior to birth. Later in life, when puberty occurs, these pathways respond to increases in testosterone which thereby allows for male-typical behaviour. Given that it is well established that this androgen facilitates aggression in many male animals it might be assumed that this is also the case in human males in general. It is certainly the case that aggression in human males increases around the time of puberty. Despite this, as evolutionist Frank McAndrew [10] has documented, in our species there is only a weak relationship between levels of aggression and circulating levels of testosterone. In fact, it is known that there is quite large cross-cultural variation in levels of physical aggression demonstrated by males suggesting that culture also plays a significant role here. There may also be individual variation in aggressive response within a given culture even where two individuals share all of their genes! (Box 3 'Behavioural epigenetics').

To complicate matters further, the amount of testosterone produced at any one time depends largely on environmental input and this is not necessarily directly related to aggressive response. Sportsmen, for example, show elevated levels of circulating testosterone during competition. This helps to promote performance (and, interestingly, after winning a game men show elevated levels of testosterone whereas those on the losing side show depletion). Finally, even though there is a relationship between testosterone and aggression, under many circumstances experts are still uncertain as to what is cause and what is effect? In other words, does a high level of testosterone lead to aggression or does acting in an aggressive manner lead to higher levels of testosterone? In conclusion research currently suggests that the main role testosterone plays is to promote competitiveness and dominance rather than aggression per se. How this competitiveness is played out is, in part, culturally determined and, in part, genetically endowed. In the words of Frank McAndrew:

"Models of aggression that focus only on situational and cognitive/emotional triggers of aggressive behavior and attempt to understand human aggression without any reference to biology are destined to be incomplete at best".

So, what is the Relationship between Genes and Behaviour?

As we have seen genes do not code directly for behaviour. They do, however, influence differences between people in their tendencies to gravitate to behavioural responses. Hence, we can say that differences between people in their genome can contribute to differences in their behaviour. How genes influence behaviour occurs over three different time frames [11].

1. Genetically influenced brain activity leads to behavioural responses on a moment-by-moment time scale depending upon environmental challenges and opportunities (see 'organizational effects' earlier). In relation to gender differences, an example of this is that a young man in a bar, on seeing a physically attractive woman, approaches her in order to make conversation. This approach behaviour is, in part, influenced by circulating androgens that stimulate areas of the hypothalamus. Note that both androgen production and the hypothalamus are modified and activated, in part, by the genes that he has inherited.
2. During development of the individual the genetic code, through interaction with environmental input (including the intra-uterine environment) influences brain development which, in turn, leads to behavioural responses (see 'activational effects' earlier). Staying with our example of a young male approaching a female in a bar, in this case, the formation of the hypothalamus during development is guided by his genetic code (likewise the cells of the testes that produce androgens). This means that the development of appropriate neural circuits in the hypothalamus is guided by the genes that he has inherited. Note that this development also requires environmental feedback, including diet and what is considered appropriate in a given culture.
3. During our evolutionary history, the process of natural selection modified the genetic code of our species to make adaptive responses more likely to the challenges of a given environment. Put simply, those individuals that did not show such gene-influenced responses were then less likely to pass on their genes to future generations. Note this is natural selection at work. Note also that, in the example above, this brief account does not of course explain why some men (and women) are gay. That is a whole other story-and one that evolutionary psychologists have considered [12].

For each of the above timescales, it is important to stress that both genes and environment need to be considered. Without environmental input we would show completely inflexible responses and fail to learn from our mistakes (and from our successes, Barkow, 1989) [13]. Whilst evolutionary psychologists do emphasise human behavioural adaptations, they consider that these are structured to respond contingently to local social and ecological factors rather than being immutable.

Box 3: Behavioural epigenetics – the new science of how the environment can influence the activity of genes
Behavioural epigenetics is a new approach that seeks to understand how nurture helps to shape nature. During the twenty first century evidence has accumulated that demonstrates how various environmental influences (positive or negative) from diet to environmental toxins to social encounters influence the expression of certain genes [14]. The expression of a gene refers to how often it is activated. It is now known that various life experiences affect which genes are active. Hence, two people who share similar or even the same genes can end up with noticeable differences in personality. One study suggested that differences in the life experiences of a pair of identical twins can have lasting effects in terms of how risk aversive each will become [15]. Such differences are believed to be related to changes in DNA methylation (a chemical reaction that turns off a gene). This, in turn, affects neuronal development in the brain. Hence an early traumatic social encounter, for example, that only one of a pair of twins experiences can lead that individual to become more risk aversive than the other in later life (because this experience led to certain specific genes being less active during early development). Epigenetics therefore helps us to understand why identical twins, despite sharing all of their genes, are never really identical in personality. Behavioural epigenetics teaches us why we cannot determine how any individual's personality will develop simply by knowing their genetic code. It also demonstrates how we need to examine both 'nature' and 'nurture' if we are to explain the development of personality.

Conclusion

To conclude, although some social scientists attempt to explain the human condition without recourse to the biological side of the equation, it is clear that, while nurture may fire the gun, without nature (that is, genes that were selected during our evolutionary history) we would have no ammunition.

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