

Original Article

ADHD and evolutionary mismatch:
A critical appraisal

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Abstract *This paper critically examines the relationship between ADHD and evolutionary mismatch. After reviewing evolutionary mismatch theory, it moves on a consideration of the genetics of ADHD and an ethnographic study of ADHD in a contemporary hunter gatherer group. Both provide some support for evolutionary mismatch theory. The paper concludes that the evolutionary mismatch theory only partially accounts for the presence of ADHD in contemporary society.*

Keywords: Evolutionary; Mismatch, ADHD , Hunter, Gatherer

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INTRODUCTION

Attention Hyperactivity Disorder ADHD, a neurodevelopmental disorder, is thought to affect about 6.1 million children and 4.4 percent of adults aged between 18-44 in the USA. It is found in 2 % adults and 3.6% of children in the UK (UK adult ADHD Network, 2013). Male rates have generally been found to exceed those of females (Skogli et al., 2013). Wedge (2012) observed that the recognition of the disorder, its diagnosis and management varies considerably both between and within countries. Differing cultural diagnostic rates may result from some cultures putting more emphasis on emotional regulation than others (Ghosh et al., 2015; Wanless et al., 2013).

ADHD is characterised by impulsivity, hyperactivity and inattention. Childhood symptoms often persist into adulthood. There has been disagreement among psychologists as to whether it is a deficit state (of executive

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functioning), or rather, a specific cognitive style that can in some ways benefit individuals. As Swanepoel et al (2022) note, some psychologists and psychiatrists view ADHD as a developmental disorder, others see it as a genetic condition, while others see it as a collection of symptoms which are impossible to distinguish from the impacts of trauma in childhood. The diagnosis is to say the least controversial and the disorder may be over- diagnosed (Timimi & Taylor, 2004). Given that ADHD can significantly reduce quality of life, has a high prevalence of psychiatric comorbidity, social and educational dysfunction and increased mortality (Ajnakina et al., 2022), why has it persisted from an evolutionary point of view?

Evolutionary Mismatch

Evolutionary mismatch is a central tenet of evolutionary psychology. The term evolutionary mismatch refers to the situation in which the environment which an organism currently inhabits differs from the one in which it originally evolved. Traits which were formally advantageous may become maladaptive due to environmental change, especially with rapid change. The term adaptive lag denotes instances in which human adaptation to their environment is slower than the rate of environmental change, resulting in a mismatch. Once adaptive traits have now become maladaptive or pathological (Cofnas, 2016). Modern day psychological faculties like cognition, emotion, and behavior evolved following challenges to survival and reproduction in past ancestral environments (Buss, 1995; Tooby & Cosmides, 1992).

Tooby and Cosmides note how: ‘our modern skulls house a stone age mind’ (Shenkman, 2016 : xv). In the modern world compared to the ancestral world, population densities are higher, there is greater dispersal of families, there is less exposure to nature, people are more sedentary, the diet consists of processed foods and substances. Therefore past evolved adaptations may interact negatively with contemporary environments. Li, Van Vugt and Colarelli (2018) note how, in modern environments, the quantity or intensity of an organism’s inputs differ from those in the past and do not have the same fitness associations. This results in mechanisms producing maladaptive outputs. Modern environments can produce novel pathological phenotypes. Evolutionary mismatch has been postulated by evolutionary psychiatrists and psychologists as a reason for the high prevalence of mental illnesses in modern industrialised societies (Chaudharary & Salali 2022; Crawford & Salmon 2002; Durisko et al., 2016; Abed & Abbas 2014).

Evolutionary approaches assert that some conditions which mental health professionals classify as disorders associated with impairment and distress may result from functioning adaptations which operate “normally” and are ‘designed’ by natural selection. Keller and Miller (2006) argue that contemporary human groups live in environments which differ significantly from those in which

evolution occurred. In their view interactions between novel environmental factors and 'ancient' alleles removal of these alleles from the population via natural selection.

Several aspects of the evolutionary mismatch hypothesis have attracted criticism. First, it has been observed that processes of behavioural flexibility and cultural evolution enable humans to rapidly adapt to local and changing conditions rather than resulting from genetic changes only. Some cultural evolutionists stress the importance of social learning in contemporary behaviour (Henrich & McElreath, 2003).

Second, descriptions of the Environment of Evolutionary Adaptation (EEA) lack empirical evidence and are speculative and vague. It is likely there were many ancestral pasts and we may indeed ask which of these were most relevant (Elton, 2008; Potts, 1998; Zuk, 2013). Cosmides and Tooby (2000) conceptualise the EEA as a statistical composite of selection pressures on the genes, rather than a specific place or time. Given that our knowledge of the EEA is sketchy, it is impossible to test selectionist hypotheses through quantitative testing.

Third, Zuk (2013) takes issue with the fact that human evolution has ceased since the Paleolithic. Evidence suggests that genetic changes in humans have occurred over the last 10, 000 years or so. Hawks, Wang, Cochran, Harpending and Moyzis (2007) point out that human evolution occurred during the Neolithic, possibly at an even faster rate than during the Paleolithic. Pertaining to evolutionary psychology, Smith (2019: 1) underscores the fact that:

'But for evolutionary psychological explanations to succeed, practitioners must be able to show that contemporary cognitive mechanisms correspond to those that were selected for in the environment of evolutionary adaptedness, that these present-day cognitive mechanisms are descended from the corresponding ancestral mechanisms, and that they have retained the functions of the ancestral mechanisms from which they are descended.'

In her view, evolutionary psychology is unable to answer these questions. Fourth, critics assert that evolutionary explanations are untestable. Adaptive hypotheses are 'just so stories' based upon reverse engineering accounts which are not possible to verify empirically. However some authors argue that, while evolutionary explanations are difficult to test, it is not impossible to test them (Buss, Haselton, Shackelford, Bleske, & Wakefield, 1998; Pinker, 1997b)." Schacter, Wegner and Gilbert, 2007).

Fifth, it is argued that evolutionary psychology ignores the relevance of non-adaptive and non -genetic mechanisms. Sixth, some authors argue that

evolutionary psychology does not (or cannot) disentangle potential adaptive bases of behavior from other evolutionary influences.

Finally, Gerstle (2018) underlines the versatility of mismatch theory which can be employed to explain any contemporary issue. It is a ‘floating signifier’-referring to the fact that it ‘is a rhetorical form with such numerous and slippery meanings that can potentially construct any argument.’

While there have been major criticisms of evolutionary mismatch theory as discussed above, there is support for evolutionary mismatch accounting for the development of diverse diseases like type 2 diabetes and cardiovascular disease in contemporary societies (Hoogland & Ploeger, 2022). These diseases are considered to result from mismatches between stressors in the ancestral environments and current environments. Such environmental stressors include food patterns (Logan & Jacka, 2014), and lack of exercise (Lieberman, 2015). Furthermore, a positive correlation has been observed between a modern lifestyle and all kinds of physical diseases (e.g., Bhatnagar, 2017; Thorburn et al., 2014). Diseases like obesity, hypertension, type 2 diabetes, coronary heart disease, epithelial cell cancers, osteoporosis, and autoimmune disease have a low prevalence in hunter-gatherers and other non-modernized populations (Carrera-Bastos et al., 2011).

Modern lifestyles including lack of exercise and the consumption of too little non -processed foods have been associated with increased rates of mental disorders like depression (Hiles et al., 2017; Sanhueza et al., 2013). There is preliminary evidence that, compared to non -industrial societies, modern societies have a higher prevalence of depression and possibly other mental disorders (Sun & Ryder, 2016). Below I argue that evolutionary mismatch may be useful in accounting for ADHD in modern day societies. I provide some evidence that genes for novelty seeking may have been advantageous in ancestral environments but result in ADHD in modern complex societies. (Eisenberg, 2008).

Contemporary Hunter Gatherers

Many arguments pertaining to evolutionary mechanisms deploy modern day hunter –gatherer groups as proxies for stone -age populations (Pontzer, Wood & Raichlen, 2018). By hunter gatherer I refer to groups which forage plants and food through hunting, fishing and gathering and do not domesticate plants and animals. Some hunter gatherer groups may store food and are more sedentary - delayed return - compared to other groups who do not do this-immediate return groups.

Gowdy (2021) notes how humans lived a hunter gatherer lifestyle for almost their whole history, approximately 300,000 years. Until 10,000 years ago

humans led a hunter gatherer nomadic lifestyle with different stressors experienced to those of contemporary industrialised societies. In contrast to modern industrialised societies, hunter gatherer societies traditionally are characterised by egalitarianism, networks involving strong social support, learning by exploration, sensitive child-rearing practices and a focus upon the present (Chaudhary & Salali, 2022). While there is very limited research on hunter –gatherer mental illness, there is some evidence for higher levels of wellbeing and lower levels of psychopathology in these groups compared to industrialised populations, possibly as a result of their childcare practices and social organisation (Chaudhary & Salali, 2022). As one example, the Tsimane of Bolivia, a forager –horticulturalist population, demonstrate a significantly reduced point prevalence of depression in the elderly compared to most other South American countries (Stieglitz et al., 2015). The authors postulate that this finding may result from the persisting involvement of the elderly in the foraging workforce and the absence of social isolation. Two recent studies indicate higher level of happiness in hunter gatherers compared to Western populations. Frackowiak et al., (2020) found this in Hadza. Reyes-Garcia et al (2021) observed this finding among the Baka, Penan and Tsimane).

We may indeed ask to what extent contemporary hunter gatherer groups can be seen as models for Paleolithic ways of life? There are problems arguing that contemporary hunter gatherers are survivors of ancient Paleolithic cultures (Dein, 2022). First, they are impacted by modernity. Contemporary hunter-gatherers are often in close proximity to developed societies and are influenced by them. As an example, the Kung San Bushmen of Southern Africa no longer have an independent foraging economy, existing instead as an underclass in an integrated market economy (Wilmsen et al., 1990). Panter-Brick, Layton and Rowley Conwy (2001: 260) state that they are not ‘immobile cultures fossilized since the Paleolithic’. These groups experience reduced food resources, demographic expansion and exposure to diseases of modern civilization like diabetes and heart disease.

While foraging groups have traditionally been deployed as proxies ancient Paleolithic cultures, it is increasingly recognised that they are heterogeneous—there are culturally and ecologically diverse modern day populations —each with its own unique social and geopolitical history influencing their social interactions with other ethnic groups and with their local habitats (Crittenden & Schnorr, 2017).

Here I ask whether ADHD had any adaptive value in the past through novelty seeking, vigilance and exploration. According to the hunter farmer hypothesis first proposed by Thom Hartmann (1997) in ‘Attention Deficit Disorder: A Different Perception’, ADHD occurs when there is a lack of adoption among populations transforming from nomadic hunter gatherer societies to permanent farming societies. Those suffering from ADHD retained some of

their hunter gather traits like hyperfocus. The traits of ADHD increased the fitness of carriers and therefore were able to spread in populations due to natural selection. This hypothesis, while speculative, is certainly plausible. More adventurous individuals who were more willing to explore were more likely to have viable offspring. The hunter farmer hypothesis asserts that specific hunter-gatherer traits would have benefitted environmentally long into the Neolithic Revolution.

Because of fast cultural evolution and its associated environmental changes over the past 10, 000 years, traits associated with ADHD have become maladaptive, failing to meet the specific demands of contemporary environments. To date mismatch theories have been speculative with little empirical data to substantiate them. However current genomic data may allow the mismatch theory to be assessed empirically.

Genetic theories of ADHD

To what extent can ADHD be considered an evolutionary mismatch? What is the evidence for the evolutionary thesis? I begin by examining the genetics of ADHD. Genetic factors are important in the aetiology of ADHD (Faraone & Larsson, 2019). ADHD is one of the psychiatric disorders with the strongest genetic basis according to Familial, twin, and single nucleotide polymorphisms (SNP)-based epidemiological studies indicate that ADHD is a psychiatric disorder with a strong genetic aetiology. Twin studies demonstrate high heritability of 70-80 % (Farone., et al 2005; Balogh, Pulay & Rethelyi, 2022). The seven-repeat (7R) allele of the human dopamine receptor D4 (DRD4) gene is closely linked to both attention-deficit/hyperactivity disorder and the personality trait of novelty seeking (Ding et al., 2002). A genetic study of early human migration found that ADHD traits were overrepresented in early populations. A gene variant coding for a specific dopamine receptor was found to be more prevalent in those populations with a long history of migration. Finally epigenetic factors may differentially impact the susceptibility of children to factors in their environment (Belsky, 2005).

While genes appear to be important for ADHD, ecological and social factors also play a significant role. Swanepoel et al (2022) stress the significance of gene environment interaction in the aetiology of ADHD. Environmental factors like insecure attachments and insensitive parenting appear to be causally related to this disorder (Harold et al., 2013; Roskam et al., 2014). Socioeconomic factors have been found to impact the prevalence of ADHD. There is evidence that early severe institutional deprivation can result in ADHD on adults (Kennedy et al., 2016). Children living in the poorer parts of the Bronx in New York has poorer self -regulation than their privileged counterparts (Mischel, 2014)

The question arises as to why the genes for ADHD might have survived natural selection? Swanepoel et al (2022) argues that ADHD traits evolved in early human hunter gatherer societies in environments that rewarded novelty seeking, risk taking and exploration. Jensen et al (1997) note how hunter-gatherer environments are characterized by resource depletion, alongside time-critical and novel-rapidly changing conditions in which hyperactivity would have been an advantage in migrating to better climates and impulsivity would enhance the fight or flight response.

ADHD traits would be useful in nomadic and migrating groups. There is evidence that, in relation to people who undergo major migrations like refugees, a higher proportion than found in the general population possess 'novelty seeking' genetic variants which are found in children with ADHD (Matthews & Butler, 2011). This might have enabled them to find a new dwelling place, to evade danger and pass on this variant. Furthermore, one evolutionary explanation for the higher male ADHD prevalence compared to females pertains to the fact that males needed to take risks to find mates than females (Bateman, 1948).

Estellar Culculla et al (2020) deployed archaic, ancient and modern human samples to study genetic changes diachronically. They deployed the largest GWAS meta-analysis available for this disorder involving than 20,000 individuals diagnosed with ADHD and 35,000 controls, to examine the evolution of ADHD-related alleles in populations from Europe. They observed a steady decrease in the frequency of variants associated with ADHD since the Paleolithic, particularly in Paleolithic populations in Europe compared to samples originating from the Neolithic Fertile Crescent. The authors argue for strong selection pressures acting against alleles linked to ADHD. Having ruled out alternative explanations like archaic introgression whereby genetic material is transferred between archaic species, they conclude that their data is compatible with the evolutionary mismatch hypothesis.

They note a higher frequency of current ADHD-risk alleles in the past. Populations are still adapting to recent environmental change which has resulted in these alleles becoming maladaptive. The data do not support the hunter farmer hypothesis since both Neolithic and modern populations both have reduced frequencies of ADHD associated alleles compared to Paleolithic populations. For them the Neolithic revolution was not the major watershed moment for ADHD pressures. The results suggest a much longer timeframe for the evolution of ADHD associated alleles than those suggested by previous hypotheses.

Evidence for Mismatch from Hunter gatherers

There is evidence that the traits of ADHD may have benefited early humans as hunter gatherers during the Paleolithic. Eisenberg et al (2008) studied the Ariaal of Northern Kenya. One main focus was the variation in the Dopamine type 4 receptor (DRD4 7R) in this group and its relation to lifestyle. Traditionally nomadic pastoralists, a small minority have settled in towns and became directly dependent upon agriculture and the market economy. About 1/7 people in this group possess the long version of the DR4 gene linked to novelty seeking. The research observed, by using BMI, that those who were more sedentary with ADHD traits were less well nourished and unhealthy than their counterparts who did not suffer with ADHD. ADHD Traits of ADHD were measured through polymorphisms in the DRD2 and DRD4 genes related to impulsivity.

Those in the nomadic community with ADHD who still had to hunt for food were better nourished than those without ADHD. Hunter gatherer skills were enhanced by having ADHD. Those in the sedentary group with the genetic variant for ADHD experienced more difficulty in the classroom. While this research indicates that those with ADHD traits may fare better in terms of nutrition, it is far from clear that this was the reason this trait was selected for in the ancestral past. Furthermore the question arises as to whether the contemporary Ariaal can be taken as models for early Paleolithic groups given the impact of modernity on them.

In another study, Tovo-Rodrigues et al (2010) examined the distribution of dopamine receptor gene D4 (DRD4) variants in South Amerindian populations with recent history of either agricultural or foraging subsistence (Guarani Kaiowá and Nandeva subgroups and Kaingang Brazilian Amerindians). Interestingly, in the study of South Amerindian populations. The research demonstrated that the frequency of the 7R allele at this locus was found to average 0.58 across the populations with a recent history of hunting and gathering in comparison to 0.48 across recent farmers. The 7R variant has been associated with novelty-seeking, impulsivity and hyperactivity. Genetic analyses point to the fact that the 7R allele underwent strong positive selection over the past 40,000 years, a period which was associated with major human expansion (Ding et al., 2002). One explanation of these findings is that hyperactivity and novelty seeking may have provided fitness benefits in hunter gatherer societies through exploration of novel environments. With increasing sedentism in the Neolithic revolution, these traits were no longer adaptive (see also Chaudharary & Salali, 2022)

CONCLUSION

In summary, while there is some evidence for the evolutionary mismatch hypothesis in relation to ADHD (Estellar Culculla et al., 2020; Eisenberg et al., 2008), there are alternative explanations for the persistence of the disorder in contemporary society. It is possible that ADHD traits persist on account of their increased success reproductively. As is widely recognised, compared with those without ADHD, those suffering from the disorder have a higher likelihood of being younger at first sexual intercourse, have greater numbers of sexual partners and are more involved in teenage parenthood (Barkley et al., 2006; Flory et al., 2006; Østergaard et al., 2017; Esteller-Cucala et al., 2020). Østergaard et al, 2017 found that teenage pregnancy rates were significantly increased in those with ADHD compared to those without ADHD.

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