

Title

How evolutionary thinking can help us to understand ADHD

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Abstract

In this article, we argue that current debates about ADHD can be considered afresh using an evolutionary lens. We look at the symptoms of ADHD and show how they can often be considered adaptive to their specific environment. We suggest that, from an evolutionary point of view, ADHD symptoms might be understood as a result of an ‘evolutionary mismatch’, in which current environmental demands do not fit with what evolution has prepared us to cope with. For example, in our ancestral environment of evolutionary adaptedness (EEA), children were not expected to sit still and concentrate on academic tasks for many hours a day. Understanding ADHD in terms of such a ‘mismatch’ raises significant issues regarding the management of childhood ADHD, including ethical ones. An approach based on the concept of mismatch would allow a more transparent discussion of these issues. It could provide an alternative to current debates on whether ADHD results from nature or nurture and whether it is under- or over-diagnosed. It would replace this with a perspective that would allow clinicians and policymakers to take both the child and the environment into account, and consider what might be desirable and feasible, both in society and for specific children, in order to lessen the mismatch.

Learning objectives

- Grasp the concept of ADHD as an ‘evolutionary mismatch’.
- Understand the issues raised by this perspective, including ethical ones
- Appreciate how a transparent discussion of these issues might inform decisions about management, medication and schooling.

Declaration of interest

The authors are members of the evo-psychotherapy study group at the Tavistock Clinic. The aim of the group is to promote evolutionary thinking in psychotherapy and psychiatry.

Article

Introduction

Few childhood conditions designated as psychiatric disorders are as mired in controversy as Attention Deficit Hyperactivity Disorder (ADHD) (Timimi and Taylor 2004). While diagnosis is generally made on the basis of behavioural checklists, there are continual debates about the status of such diagnoses. Some mental health professionals see ADHD as a developmental disorder, some as genetically driven, while others see a set of symptoms that are indistinguishable from the effects of trauma on children.

In a previous paper (Swanepoel et al. 2016) we argued that the traditional disease model, still dominant in psychiatry, is less than ideal for making sense of a range of psychological issues such as the effects of early childhood experiences on

development. We argued that a model based on evolutionary thinking can deepen understanding and aid clinical practice by showing how behaviours, bodily responses and psychological beliefs tend to occur for reasons that are evolutionarily adaptive, even when these might on first appearance seem pathological.

In this paper we apply this reasoning to Attention Deficit Hyperactivity Disorder (ADHD), the most commonly diagnosed neurodevelopmental disorder (Thapar and Cooper 2016). ADHD, characterised by hyperactivity, impulsivity and inattention, appears to be linked with serious consequences, including educational failure, substance abuse and criminal involvement. The prevalence of diagnosis seems to be increasing, but the reasons for this are hotly disputed (Thapar and Cooper 2016).

Here, we do not argue for a single explanation for the widespread occurrence of ADHD. Indeed, we caution against too simplistic an understanding of the condition – including a belief either that all ADHD diagnoses are faulty or that the condition can always be objectively identified and straightforwardly treated with medication. Our hope is that an evolutionary perspective will prove useful to clinicians and others faced with high rates of referrals of children (or adults) presenting with symptoms of ADHD. We argue that the environment of evolutionary adaptedness (EEA) did not prepare children to sit still and concentrate for hours every day and that this difficulties that many children experience can be understood in terms of this mismatch. See Box 1 for a definition.

ADHD classification and identification

In DSM-4, ADHD fell under ‘disruptive behaviour disorders’, along with oppositional defiant disorder, intermittent explosive disorder and conduct disorder. In DSM-5, ADHD was moved into the category of neurodevelopmental disorders, alongside autism spectrum disorders, intellectual disabilities, communications disorders and motor disorders. A neurodevelopmental disorder is one in which "the development of the central nervous system is disturbed". Common characteristics of ADHD are that the onset is in early childhood, that there are cognitive as well as behavioural deficits, and that the symptomatic and functional impairments tend to persist. There is typically a male preponderance and these disorders tend to have a degree of heritability. There is a large overlap of different neurodevelopmental disorders – co-occurrence is the rule rather than the exception (Posner et al. 2014; Dyck et al. 2011)

In support of a neurodevelopmental view, the Ben-Gurion infant development study shows that sons of fathers with ADHD are more irritable and that there are more inadequate responses to their needs than control sons of fathers without ADHD (Auerbach et al. 2004). The at risk infants were more irritable and indicated less clearly what was bothering them, making parenting them more difficult. This was confirmed by Elberling et al. (2014) who found that mother-infant interaction problems were more likely. Interestingly, expressed emotional (parental hostility) is child-specific, not parent-specific (Cartwright et al. 2011).

Only 10% of clinic samples of pre-schoolers diagnosed with ADHD are in the normal range at 15-18 years – thus there is continuity (Lahey et al. 2016). Persistent

classroom inattention is a strong predictor of *not* obtaining a high school diploma at age 22 (Pingault et al. 2011). ADHD in pre-school boys is associated with a 10-point reduction in General Certificate of Secondary Education (age 16) scores (Washbrook et al. 2013). There is a 7-12 point average IQ deficit in individuals with ADHD (Simonoff et al. 2007), though there is considerable variability and some individuals with ADHD have well above average IQs. It has also been shown that preschool ADHD incurs a 17-fold economic burden due to increased needs in health, education and social care and makes it more likely that children would be bullies or the victim of bullying (Verlinden et al. 2015).

There are no discernible differences in the brains of infants with ADHD (Ghassabian 2013); however, by age 6-8 years, children with ADHD had thinner cortices in the primary somatosensory area (Mous et al. 2014). Adults with ADHD have also been found to show abnormal reactivity in this area (Dockstader et al. 2009), although new studies show that there is not necessarily continuity between childhood and adult ADHD. Some have argued that the criterion that ADHD must have started before the age of 12 should therefore be dropped (Caye et al. 2016).

Epidemiological issues

One notable fact about ADHD is that rates of recognition, diagnosis and treatment vary widely between and within countries. In 2012, at least 9% of school-aged children in the US were diagnosed with ADHD; the corresponding figure for France was less than 0.5% (Wedge 2012). The rate of ADHD diagnosis in pre-schoolers varies too, even between quite similar countries: in Denmark it is 1% (Elberling et al. 2016) while it is 3.8% in Iceland (Gudmundsson et al. 2013). The rates even differ substantially across states in the USA (Fulton et al. 2015). They have also increased considerably in many countries, including the USA and UK, in recent decades. Such variations may be due to differences in how the condition is defined and the ways data are gathered (Polanczyk et al. 2014).

Another significant finding about ADHD diagnosis is that in large samples in many countries it is clear that there is a hugely increased likelihood of ADHD diagnosis if a child is in the youngest group in a school year cohort. For example, children in Denmark born just before the cut-off for the next year were about 2.5 times more likely to have an ADHD diagnosis (Krabbe et al. 2014) and similar results have been seen in a swathe of countries such as Germany (Schwandt and Wuppermann 2016), Canada (Chen et al. 2015), Taiwan (Chen et al. 2016) and Israel (Hoshen et al. 2016). At the very least, this suggests an increase in diagnoses in children who are less emotionally mature, and less able to be still.

There are also cultural differences in diagnosis rates (Ghosh et al. 2015), which might be explained by some cultures placing higher value on emotional regulation as a value and/or a range of other factors. Problems with self-regulation are more common in US than Asian males, for example (Wanless et al. 2013). Cultures that value close bodily contact and a quick response to signals of distress, and where there are clear imperatives for children to abide by rules, are ones where self-regulation develops earlier and more fully. Children in more interdependent cultures are also quicker to develop skills in compliance and emotional regulation (Wanless et al. 2013),

especially boys. Despite these anomalies, it is nevertheless clear that there are a group of children, principally boys, who are showing symptoms (identified as ADHD) that cause concern and whose longer-term trajectories might not be good (Thapar and Cooper 2016).

Genes, epigenetics and adaptation

According to evolutionary thought, behaviour traits that have survived and been passed down the generations must have had adaptive value in the past, and possibly still have today. It is certainly conceivable, for example, that more adventurous individuals in hunter-gatherer society sometimes did better in terms of leaving viable offspring perhaps because they were more willing to explore (see Box 2). It is worth asking why it could be adaptive for a child to have a version of a gene or set of genes that appears to give rise to such a poor prognosis as ADHD. It seems that such a 'temperament' might well be advantageous in some environments. For example, when we examine the genes of people involved in major migrations, such as refugees, we see that a higher proportion than average have the same 'novelty seeking' genetic variant that is associated with ADHD in children (Matthews and Butler 2011). One can speculate that being a carrier of that novelty seeking variant might have aided the likelihood of survival by making such individuals more predisposed to seek new pastures when danger loomed, and hence survive to pass on this variant.

Although genes alone are most unlikely to cause ADHD symptoms, gene-environment interaction is looking increasingly likely to play a central role. It seems, for example, that carriers of the long allele of the DRD4 (7 repeat allele) are more likely to show ADHD symptoms (Faraone et al. 2014) and this genetic variant also increases the likelihood that children will be novelty seeking. For these children, insensitive parenting in the early years predicts more externalising behaviours, although this is not the case for carriers of the short variant (Windhorst et al. 2015). Inheriting this allele also predicts worse emotional regulation, and indeed more likelihood of disorganised attachment presentations (Pappa et al. 2015). Thus, this and other genes may predispose for ADHD, but will only ever be a partial explanation.

Interestingly, one study looked at hyperactive children who were adopted (Harold et al. 2013). Where these adopted children received sensitive and attuned parenting the symptoms of hyperactivity were not subsequently seen. As so often, we find that experiences and genes, nature and nurture, interact to produce their effects (van Ijzendoorn and Bakermans-Kranenburg 2015). Thus, what we are seeing is that some children are born with more genetic susceptibility for ADHD-type symptoms but also that certain kinds of environmental influences, such as cultural values or parenting, including closely monitoring a child's behaviour, can hugely reduce the potential effects of genes that otherwise might give rise to worrying behaviours.

Epigenetic research is showing that some children are more susceptible to the influence of their environment than others, what Belsky and others have called 'the differential susceptibility to rearing' influence (Belsky 2005). Belsky has argued that successful reproduction of one's genes is more likely if some of one's offspring are more influenced by the current environment than others, as in such scenarios, in the face of both continuity and major change, offspring will survive to pass on their genes. Thus, we now think not of vulnerability genes (e.g. for ADHD) but rather in

terms of relative plasticity (Belsky and Hartman 2014), because some people are simply more influenced by experiences than others, due at least in part to their genes.

Environmental influences

There have been a number of studies linking quality of parenting to ADHD diagnosis, concluding that ADHD is related to insecure attachment relationships (e.g. Roskam et al. 2014). What much research makes clear, and accords with common sense, is that if we are relaxed and at ease we are less likely to be as vigilant and jumpy than if we are in an environment which is stressful or dangerous. Research (Tronick 2007) as well as infant observation over many decades, such as in the Tavistock model (Miller 1989), has shown how even young infants, when feeling less emotionally held, move around more and are less able to concentrate. Infants and children feel calm, more relaxed and stiller when their emotional and physiological states are regulated by an adult attuned to them. Studies show that having a stressful or traumatic childhood is highly predictive of being impulsive, dysregulated and having poor executive functioning (Ersche et al. 2012). In families displaying high levels of negativity, anger or aggression, children tend to struggle much more with emotional regulation (Morris et al. 2007). Indeed, where there is violence and aggression we see extreme sympathetic nervous system arousal alongside the externalising behaviours (El-Sheikh et al. 2009, Panzer 2005).

From the perspectives of Life History Theory (Belsky et al. 2012), a speeded up metabolism, less trust, less relaxation and more suspicion and risk-taking might be adaptive for abusive homes or violent neighbourhoods. In such environments there is little emotional security or expectation that things will work out well. It is a strategy that ensures short-term survival, though at the cost of long-term physical and mental health. Our responses can therefore be seen as adaptive to our environments, triggering neurobiological patterns that have a profound effect on the rest of our lives (Belsky et al. 2012). Those born into highly stressed worlds tend to have a speeded up metabolism and more activated stress response systems and develop what some call a 'fast' as opposed to a 'slow' life history strategy. We see this in a range of other mammals as well as in humans, and it is a strategy that aids survival. Without it, any too trusting and complacent ancestors might well have met a violent end before they had time to reproduce. In many circumstances the best response is to be wary, vigilant and untrusting.

Evidence shows that ADHD symptoms increase due to social and economic as well as parenting influences. For example, Mischel (2014) found that children from low-income families in violent parts of the Bronx tended to have below average ability to self-regulate compared to more privileged children. Early severe institutional deprivation is associated with adult ADHD (Kennedy et al. 2016). Other studies have found a link between low socio-economic status and the growth of executive parts of the brain (Noble et al. 2005), even linking poverty with chronic stress and neurocognitive outcomes right up into adulthood (Evans and Schamberg 2009). Indeed, by six months infants from socio-economically deprived environments are less able to pay attention (Clearfield and Jedd 2013). Childhood poverty and the associated stress levels have a big effect on capacities for emotional regulation, the

development of inhibitory brain networks (Kim et al. 2013) and the likelihood of increased risk-taking (Griskevicius et al. 2011). Being able to defer gratification depends on feeling sufficiently relaxed (high vagal tone) and being helped to bear and regulate one's emotions (Moore and Macgillivray 2004).

ADHD can be thought of in part as a deficit of Executive Functions (Barkley 2006) – although many forms of executive functioning disorders are unrelated to ADHD. Those diagnosed with ADHD struggle, for example, with planning, emotional regulation, focusing, concentrating, putting plans into action – all of which are aspects of executive functioning (Brown 2013). Those able to delay gratification have more activity in prefrontal brain regions, central to abstract thinking, planning, working memory and emotional regulation – again, all of which are aspects of executive functioning (Barkley 2012). Those with more impulsive character traits tend to lack these prefrontal 'brakes' on their impulsivity (McClure et al. 2004). Instead, more primitive subcortical brain areas are active. This also is seen in trauma and in stressful situations generally, which is partly why many children who display symptoms that fit with ADHD checklists for other reasons are misdiagnosed as having ADHD (DeJong 2010).

Social changes

The social environment for children has changed dramatically over the past century or two. Whereas most boys would once have typically learnt a trade from their father or other relative, this all changed with the professionalisation of schooling. One result of this is that there is a mismatch between the strengths of children with ADHD – i.e. their tendency to explore, to challenge and to try out new ways of doing things – and their environment (today's schools).

Why are male rates typically higher than those for females? One common evolutionary explanation for differential rates like these is that males have had to be more risk-taking to compete for mates, since a higher proportion of males than females fail to have children and pass on their genes. Thus, sexual competition between adult males is high, and this can be compounded when males have to leave their families to seek out mates. Also, boys are more sensitive than girls to the consequences of sub-optimal parental care. From birth onwards girls on average are better equipped to regulate their emotions, and are less badly affected by disruptions in parenting. Parents may need to work harder to imitate and respond to their sons than their daughters, and researchers have suggested that boys need more input in order to feel emotionally regulated (Tronick and Weinberg 2000). Following postnatal depression it seems boys tend to fare worse, having less capacity for object constancy at 18 months and showing more behavioural problems at school age (Murray et al. 1993). Sander (2007) looked at new-borns separated from their parents and placed with new carers. After a few days the girls had all entrained to their new carers' day-night rhythms but the boys took several days longer to adjust, suggesting they were more vulnerable following disruptions of care.

Tronick (2007) found that depressed mothers consistently showed angrier emotional expressions to their sons than to their daughters. By six months the boys were gesturing more anxiously, and were three times more likely than female babies to

resort to self-comforting strategies such as sucking their thumbs. It seems that boys generally are more demanding of their interactive partners. A recent study in France showed that mothers with a propensity for depression were more likely to become depressed if they had male babies (de Tychey et al. 2008), who were presumably more demanding than female ones. Such research might suggest a trade-off in evolutionary history between the need to be risk-taking and explore and the capacity to concentrate and be still. Some ADHD symptoms might still (in contemporary society) make adaptive sense, such as being vigilant and wary in the face of violence and prioritising survival and safety over the kinds of capacities which depend on prefrontal brain capacities such as empathy, self-reflection and emotional regulation (Music 2016).

However, it is possible that these adaptations might backfire in contemporary society where schooling and academic pressure is so important. ADHD is unusual as a diagnosis is most often made in the context of schooling with most cases being diagnosed in children between the ages of 6 and 12 (NHS Choices 2016).

In a typical school classroom with 25 or more young people, ADHD symptoms will affect other children in the classroom and a teacher's very capacity to teach. As the website 'ADHD Solutions' puts it in its opening sentence: "Children / young people with ADHD are some of the most challenging children that you will ever come across!" (ADHD Solutions n.d.).

The standard model of schooling in which 20 or more young people of the same age are taught in classrooms for about five hours a day, five days a week, 200 days of the year for ten years from age six certainly runs counter to our evolved behavioural strategies. Schooling therefore favours some young people at the expense of others, including those with ADHD. To add to this issue, schools, especially primary ones, can be seen as feminised institutions, with the large majority of teachers in such schools being women. Indeed, in England in 2014, 80% of the total teaching workforce in state-funded schools (primary and secondary) was female (DFE 2014). As we have noted, ADHD predominantly affects males with childhood and adolescent ADHD male:female identification ratios varying from 3 in Norway to 16 in Austria (ADHD Institute n.d.). This gender imbalance decreases with age. It is likely that schools typically favour the sorts of fairly passive, acquiescent behaviours that society all-too-often deems particularly appropriate for females.

Treatment

The main treatment types for ADHD are either medication or psychological interventions. Methylphenidate improves irritability in ADHD (MTA study, de la Cruz 2015). A Cochrane meta-analysis showed that Methylphenidate improves teacher ratings of ADHD and does not cause serious adverse effects, however, the data quality is poor (Storebø et al. 2016). Psychological interventions for ADHD show small effects on unblinded outcomes, but no effect on blinded outcomes (Abikoff et al. 2015).

There is accordingly a lot of controversy about the treatment of ADHD, with two main opposing camps. On the one hand, there is some evidence to show that ADHD has a biological component and responds to stimulant treatment (at least in the short

term) and that children who are treated generally have better educational outcomes and are less likely to abuse drugs or get in trouble with the law (Thapar and Cooper 2016). On the other hand, many clinicians argue that normal children are being medicated to make them compliant and ‘less naughty’ and that medication is being used as a form of social control. Even among ourselves as authors, we are not of one mind on these questions.

Newer evidence shows that there is a differential susceptibility regarding the development of oppositional defiant disorder and conduct disorder in children genetically more susceptible to developing ADHD (Bakermans-Kranenburg and van IJzendoorn 2015). These children will be more likely to develop ADHD and the attendant serious behavioural complications if experiencing low warmth in their relationships with their caregivers – but will be *less* likely than average children to develop these difficulties if they experience warm parenting. It is therefore too simplistic to just link genetic traits to outcomes: once again, there are significant gene-environmental interactions at play.

From an ethical point of view, there is a serious question that needs to be asked: ‘Should psychiatrists prescribe medication to facilitate a child fitting into an environment that is not ideal?’. Many ADHD services do not have any behavioural support services to which they can refer. This puts pressure on psychiatrists to prescribe, even if psychological or social measures might have been more appropriate’. It is also questionable whether prescribing is ethically justifiable when it is undertaken because of the shortcomings of the school environment. Furthermore, there clearly often is a conflict of interest in what is best for the child and what is easiest for parents and teachers. In a rare study that examined the views of children with ADHD, Singh (Singh 2012)) found that in both the UK and the US, children wanted more treatment options outside of medication but that these were not available. The question of informed consent becomes difficult with younger children, who are completely dependent on their parents. On a wider level, there are important ethical considerations for health, education and social care services (Richards 2013). Some of the complexities that can arise are illustrated by the case vignettes in Box 3.

Conclusions

We believe that an evolutionary perspective, which points out the mismatch between biological predispositions and current environments, including schools, has a lot to add to debates about ADHD diagnosis and treatment. This paves the way for a more informed discussion about whether to medicate or not. Understanding ADHD as a biological variant in some individuals, which has adaptive value for living in unpredictable situations, may help shift perceptions of the child as being ‘naughty’ to seeing someone caught in an evolutionary mismatch. Behavioural strategies in school, for example, could then focus on allowing plenty of physical activity and a fidget toy to fiddle with when having to sit still, as well as ensuring that the child makes eye contact before giving a single instruction. Longer-term, we may need to rethink how schools are organised, conceptualised and run. The emphasis in schooling is increasingly only on academic subjects. Subjects that involve movement and the development of physical skills (PE, metalwork, home economics, etc.) have largely disappeared from the curricula in a number of countries.

For people with ADHD, it may help to understand what their strengths are and to seek jobs where these are valued, e.g. in sport, adventure tours, the military or any other job where physical activity and rapid decision-making is highly valued. Of course, there are downsides to having ADHD – such individuals are more likely to perform poorly in cognitive tasks, die in accidents and get involved in criminal activity. They are also more likely to follow a fast life history strategy and tend to have more children at a younger age in whom they invest less – this may lead to an intergenerational transmission of problem behaviours linked with a biological susceptibility to ADHD.

In sum, we believe that an evolutionary view can help both professionals and patients understand ADHD in a broader sense, where it can be thought about as both a liability and a strength, and where the environment should be adapted as much as possible before using medication to adapt the individual.

Boxes:

Box 1: Evolutionary mismatch

When the environment in which an organism lives is significantly different to that in which it evolved, traits that were once adaptive may become pathological. This is termed an “evolutionary mismatch” (Cofnas 2016). One example is that humans evolved to survive food scarcity by craving and eating high calorie foods when these were available. In the current environment of plentiful food, this leads to widespread obesity. It is important to note that a trait which may have conferred survival advantage in the past, may lead to vulnerability to disorder if the environment changes. This is termed an evolutionary mismatch.

Box 2: Example of how gene associated with ADHD may have been adaptive

About one seventh of a Kenyan tribe, the Ariaal, have the long version of the *DRD4* gene, which is associated with novelty seeking. The Ariaal have either a nomadic life, moving from place to place, or a more settled pastoral life. Those with the novelty-seeking allele, who lived a nomadic life were well nourished and healthy. In contrast, those with this same allele living a settled pastoral life were on average less well nourished (Eisenberg et al. 2008). It seems that having the ‘ADHD-inducing’ variant might well be a better option when living a less settled kind of life, and that different genetic variations aid survival or success in some environments but not others.

Box 3: Case vignettes to illustrate the range and complexities of children with a diagnosis of ADHD

A 16-year old boy who was diagnosed with ADHD at age 8 and treated with stimulant medication until he finished his GCSEs was able to stop using medication when he went to a football college. He explained that at college they do two hours of football training and then break for an hour of Maths, before doing another two hours of training and then having a lesson of English. He said that this worked very well for

him and he was able to sit still and concentrate without needing medication in these circumstances.

A nine-year old boy, who was on a Child Protection Plan due to neglect by his drug-abusing mother, was treated with stimulant medication for ADHD. After he was placed in foster care, his school work improved dramatically and he was able to stop his medication. One of the reason for this was that the ‘breakfast’ his mother had assured professionals she was giving him with his stimulant medication before school, consisting of a can of caffeinated energy drink.

A 14-year old boy was on the verge of exclusion due to his disruptive behavior in class, fighting in the playground and rudeness to teachers. He had been diagnosed with ADHD at age eight, but his parents were opposed to medication. The family agreed to a trial of stimulant medication, which was a resounding success. The boy explained how he was now able to concentrate and think before he acted. He thrived on the positive feedback he was getting at school and his behavior and attainment improved.

A seven-year old boy treated with short-acting ADHD medication to cover him at school, had neighbours in the flat below complaining about his jumping around in the evenings and on weekends, which they found disturbing. Members of the multidisciplinary team agreed that medication should not be prescribed in this instance and decided to write a letter to Housing instead.

MCQs: select the single best option for each question stem

1. Viewing ADHD as an ‘evolutionary mismatch’ means:

- a. there is a single explanation for the widespread occurrence of ADHD
- b. all diagnoses of ADHD are faulty
- c. the condition can always be objectively identified
- d. previous selection pressures have not adapted us to our present environment
- e. diagnosis can made using behavioural checklists.

22. The fact that ADHD is so much rarer among children in France than in the US is most likely due to:

- a. the presence of far more child psychiatrists in the US compared to France
- b. different cultural presumptions between the two countries as to what behaviour constitutes ADHD
- c. better school food in France
- d. higher rates of teenage pregnancy in the US
- e. higher rates of divorce in the US

33. The most likely explanation as to why younger children in a school year are more likely to be diagnosed with ADHD is that such children:

- a. are more likely to be bullied
- b. need to go to the toilet more often
- c. have more difficulties sitting still and paying attention to their teachers
- d. are behind their peers in respect of reading and writing
- e. are less likely to make friends with their peers

44. Which of the following is NOT TRUE regarding infants at high-risk of ADHD:

- a. They are more irritable than controls
- b. They signal their needs less clearly
- c. They are parented less effectively
- d. They experience more hostility from their parents
- e. Their parents are more hostile in general.

55. Which of the following concepts from evolutionary science explains the high prevalence of ADHD in school-aged children:

- a. Fast life history, in which the emphasis is on ensuring short-term survival even if at the cost of long-term suffering
- b. Mismatch, in which our ancestral environment did not prepare us for current environmental demands
- c. Evolutionary trade-off between physical fitness and academic excellence
- d. Natural selection of active children
- e. Survival of the fittest favours children who can work on their own.

Answers: 1d, 2b, 3c, 4e, 5b

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