Chapter

15

Evolutionary Perspectives on Neurodevelopmental Disorders

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Abstract

We discuss evolutionary perspectives on two neurodevelopmental disorders: attention deficit hyperactivity disorder (ADHD) and autism spectrum disorder (ASD). Both have a genetic background, and we explore why these genes may have survived the process of natural selection. We draw on the concept of evolutionary mismatch, in which a trait that may have conferred advantages in the past can become disadvantageous when the environment changes. We also describe the non-genetic influences on these conditions. We point out that children with neurodevelopmental conditions are more likely to suffer maltreatment, so it is important to consider both the genes and the environment in which children have grown up. In hunter-gatherer societies, ADHD may have favoured risk-taking, which may explain why it has survived. The contemporary model of schooling, in which children are expected to sit still for many hours a day, does not favour this. Understanding ADHD in terms of an evolutionary mismatch therefore raises ethical issues regarding both medication and the school environment. ASDs are far more heterogeneous and are characterised by high heritability and low reproductive success. At the severe end of the spectrum, ASD is highly disadvantageous and often co-occurs with intellectual disability. On the other hand, high-functioning ASD may have been adaptive in our evolutionary past in terms of the potential for the development of specialist skills and can still be so today in the right environment.

Keywords

ADHD, autism spectrum disorders, evolutionary mismatch, evolutionary perspectives, neurodevelopmental disorders

Key Points

- Evolutionary thinking can deepen our understanding and aid our clinical treatment of childhood developmental disorders.
- The concept of evolutionary mismatch can be particularly helpful in understanding the relatively high prevalence of certain neurodevelopmental disorders. The concept refers to traits that may have conferred advantages in the past but now, given changes in the environment, may be disadvantageous.
- In our evolutionary past, children were not expected to sit still and concentrate on academic tasks for many hours a day. Attention deficit hyperactivity disorder (ADHD) may have favoured adaptive novelty-seeking and risk-taking. Understanding ADHD in terms of an evolutionary mismatch raises significant issues regarding the management of childhood ADHD, including ethical ones.
- Autism spectrum disorders (ASDs) are highly heterogeneous but are characterised by high heritability and low reproductive success. At the more severe end of the spectrum, if accompanied by intellectual disability, ASDs can be highly disadvantageous. On the other hand, high-functioning autism may have been adaptive in our evolutionary past and can be so today in the right environments.

15.1 Introduction

As clinicians and scholars, we believe that the traditional disease model – still dominant in

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psychiatry – is less than ideal for making sense of a range of psychological issues, including developmental problems in childhood (Swanepoel et al., 2016). We also believe 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. Our wish is to demonstrate the way that evolutionary arguments can make a contribution to helping young people who present with patterns of behaviour that indicate neurodevelopmental diversity or atypicality.

We draw particularly on the concept of 'evolutionary mismatch'. This is said to occur when the environment in which an organism lives is significantly different from that in which it evolved, so that traits that were once adaptive may become, in effect, pathological. One widely accepted example of this is that humans evolved to survive periods of food scarcity by craving and eating high-calorie foods when these were available. In the current environment of plentiful food for many of us, this leads to widespread obesity. Thus, a trait that conferred survival advantage in the past can lead to vulnerability to disorder if the environment changes (Cofnas, 2016). Here, we apply this reasoning to the two most commonly diagnosed neurodevelopmental disorders: attention deficit hyperactivity disorder (ADHD) and autism spectrum disorder (ASD).

We do not argue for a single explanation for these conditions. Indeed, we caution against too simplistic an understanding of them, including the belief that all such diagnoses are faulty or that the conditions can always be objectively identified and straightforwardly treated. Instead, our hope is that an evolutionary perspective will prove useful to clinicians and others working with children (or adults) presenting with these problems.

15.2 Attention Deficit Hyperactivity Disorder

15.2.1 Identification and Classification

ADHD is characterised by hyperactivity, impulsivity and inattention, and it appears not infrequently to be linked with serious consequences, including educational failure, substance abuse and criminal involvement. Few childhood conditions designated as psychiatric disorders are as controversial (Timimi and Taylor, 2004). While diagnosis is generally made on the basis of behavioural checklists, there are ongoing debates about the status of such diagnoses. The prevalence of diagnosis seems to be increasing, but the reasons for this are hotly disputed (Thapar and Cooper, 2016). Some mental health professionals see ADHD as a developmental disorder, some as being genetically driven, while others see it as a set of symptoms that are indistinguishable from the effects of trauma on children.

In the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV), ADHD fell under 'disruptive behaviour disorders'. In DSM-5, ADHD was moved into the category of neurodevelopmental disorders, alongside ASD and intellectual disabilities. A neurodevelopmental disorder is one in which the development of the central nervous system is disturbed. Common characteristics of ADHD are onset in early childhood, cognitive as well as behavioural deficits and symptomatic and functional impairments that tend to persist. There is typically a male preponderance, and these disorders tend to have a degree of heritability. There is a large overlap with different neurodevelopmental disorders – co-occurrence is the rule rather than the exception (Dyck et al., 2011; Posner et al., 2014).

In support of a neurodevelopmental view, the Ben-Gurion Infant Development Study showed that sons of fathers with ADHD are more irritable and responses to their needs are less adequate than in sons of fathers without ADHD (Auerbach et al., 2004). At-risk infants were both more irritable and indicated less clearly what was bothering them, making parenting more difficult. This was confirmed by Elberling et al. (2014), who found that mother–infant interaction problems were more likely. Interestingly, expressed emotion (parental hostility) is child-specific not parent-specific (Cartwright et al., 2011).

Only 10% of clinic samples of preschoolers diagnosed with ADHD are back in the normal range at 15–18 years (Lahey et al., 2016). In England, ADHD in preschool boys is associated with a 10-point reduction in General Certificate of Secondary Education (age 16) scores (Washbrook et al., 2013) and there is a 7–12-point average IQ deficit in individuals with ADHD

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(Simonoff et al., 2007). It has also been shown that preschool ADHD incurs a 17-fold lifetime economic burden to the state due to increased needs in health, education and social care, and preschool ADHD makes it more likely that children will be bullies or the victims of bullying (Verlinden et al., 2015).

15.2.2 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 USA were diagnosed with ADHD; the corresponding figure for France was less than 0.5% (Wedge, 2012). The rate of ADHD diagnosis in preschoolers 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. 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 is that in many countries there is a substantially 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). Similar results have been seen in other countries, including Germany (Schwandt and Wuppermann, 2016), Canada (Chen et al., 2015), Taiwan (Chen et al., 2016) and Israel (Hoshen et al., 2016). 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 other factors. Problems with self-regulation are identified as being 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. It is nevertheless clear that there are children, principally boys, who show symptoms identified as ADHD that cause concern everywhere and whose longer-term trajectories are often not good (Thapar and Cooper, 2016).

15.2.3 Genes, Adaptation and Epigenetics

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 have such value today. It is certainly conceivable 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 15.1).

It is worth asking why it might 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. The likely answer is that such a temperament might 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 associated with ADHD in children (Matthews and Butler, 2011). Being a carrier of that novelty-seeking variant might have increased the likelihood of survival by making such individuals more predisposed to seek out a new place to make a home when danger loomed and hence survive to pass on this variant.

Box 15.1 Example of how a 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 and who lived a nomadic life were well nourished and healthy. In contrast, those with the novelty-seeking allele but living a settled, pastoral life were on average less well nourished (Eisenberg et al., 2008).

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Genes alone do not cause ADHD symptoms, and gene–environment interactions look increasingly likely to play a central role. It seems, for example, that carriers of the long allele of the *DRD4* gene (the 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 the long allele also predicts worse emotional regulation and a greater likelihood of disorganised attachment presentations (Pappa et al., 2015). Hence, this and other genes may predispose for ADHD, but this can only ever be a partial explanation.

Another study looked at hyperactive children who were adopted (Harold et al., 2013). Where these children received sensitive and attuned parenting, the symptoms of hyperactivity were not subsequently seen. Again, we find that 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 can greatly reduce the potential effects of genes.

Epigenetic research shows that some children are more susceptible to the influence of their environment than others – what Belsky and others have called 'differential susceptibility to rearing' (Belsky, 2005). Belsky has also 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. In such scenarios, at least some offspring will survive to pass on their genes. Thus, we now think not in terms of vulnerability genes but relative plasticity (Belsky and Hartman, 2014).

15.2.4 Environmental Influences

There have been a number of studies linking quality of parenting to ADHD diagnosis, suggesting that ADHD is related to insecure attachment relationships (e.g. Roskam et al., 2014). What the research makes clear is that children with a relaxed disposition are less likely to be vigilant in an environment that is stressful or dangerous. Research has also shown how even young infants, when feeling less emotionally held, move around more and are less able to concentrate (Miller, 1989; Tronick, 2007). Infants and children feel calm and are 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 and 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 externalising behaviours (El-Sheikh et al., 2009; Panzer and Viljoen, 2005).

From the perspective 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. This 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 not just a speeded-up metabolism and more activated stress response systems; they may also develop what some call a 'fast' as opposed to a 'slow' life history strategy. This also happens in a range of other mammals as a strategy that aids survival. Without it, any too trusting and complacent ancestors might have met a violent end before they had time to reproduce.

Evidence shows that ADHD symptoms can increase due to social and economic influences. For example, Mischel (2014) found that children from low-income families in violent parts of the Bronx tended to have a 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 socioeconomic status and the growth of executive parts of the brain (Noble et al., 2005), linking poverty with chronic stress and neurocognitive outcomes into adulthood (Evans and Schamberg, 2009). At six months, infants from

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socioeconomically deprived environments are less able to pay attention (Clearfield and Jedd, 2013). Childhood poverty and its 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). Those diagnosed with ADHD struggle, for example, with planning, emotional regulation, focusing, concentrating and putting plans into action (Brown, 2013). Those able to delay gratification have more activity in prefrontal brain regions, which are central to abstract thinking, planning, working memory and emotional regulation (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).

15.2.5 Social Changes

The social environment for children has altered dramatically over the past two centuries. Whereas boys would typically have learnt a trade from their father or other relative, this changed with universal schooling. One result 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.

Why are male rates for ADHD typically higher than those for females? One common evolutionary explanation is that, as in many species, 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 (Bateman, 1948). Thus, sexual competition between adult males is high. This can be compounded when males have to leave their families to seek out mates. Boys are also more sensitive than girls to the consequences of suboptimal parental care. From birth onwards girls, on average, are better equipped to regulate their emotions and better able to cope with disruptions in parenting. Parents may need to work harder to imitate and respond to their sons than their daughters, and boys need more input in order to feel emotionally regulated (Tronick and Weinberg, 2000). Following postnatal depression, it seems boys 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 newborns 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 that they were more vulnerable following disruptions of care.

Tronick (2007) found that depressed mothers were consistently angrier with sons than daughters. By six months sons were gesturing more anxiously and were three times more likely than daughters to resort to self-comforting strategies such as sucking their thumbs. A 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). Such research might suggest a trade-off in evolutionary history between the need to be risk-taking and to explore and the capacity to concentrate and be still. Some ADHD symptoms might still make adaptive sense today, such as being vigilant and wary in the face of violence, thus prioritising survival and safety over capacities such as empathy, self-reflection and emotional regulation (Music, 2016). However, it is also possible that these adaptations could backfire in contemporary society where schooling and academic pressure are so important. A diagnosis of ADHD is most often made in the context of schooling, with most cases being diagnosed in children between the ages of 6 and 12 (NHS, 2018). In a typical school classroom with 25 or more young people, ADHD symptoms will affect other children in the classroom and a teacher's capacity to teach.

The standard model of schooling in which 20 or more young people of the same age are taught in classrooms for about 5 hours a day on most days of the year for 10 years certainly runs counter some of our evolved behavioural strategies. Schooling therefore favours some young

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people at the expense of others, including those with ADHD (Swanepoel et al., 2017). To add to this issue, schools – especially primary ones – can be seen as feminised institutions, with the large majority of teachers being women. In England in 2019, 76% of the total teaching workforce in state-funded schools was female (DfE, 2020). As has been 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, 2019). This gender imbalance decreases with age. It is likely that schools typically favour the sorts of passive, acquiescent behaviours that society often deems particularly appropriate for females. A 'good student' is essentially defined as a slow life history strategist with traits such as self-management, relationship skills, responsible decision-making and setting and achieving positive goals (Ellis et al., 2017). This leads to a mismatch between what schools want and what children with ADHD are adapted for.

15.2.6 Treatment

The main treatment approaches for ADHD are medication and psychological interventions. Methylphenidate improves irritability in ADHD (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 un-blinded outcomes but no effects on blinded outcomes (Abikoff et al., 2015).

There is 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 with medication have generally 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 that medication is being used as a form of social control. We ourselves are not of one mind on these questions.

We would all argue, however, that a 'one-size-fits-all' approach to school instruction is not appropriate and that the standard practice of teaching and evaluating children under quiet, controlled environmental conditions can disadvantage children with ADHD. Indeed, some studies have shown that children with ADHD may show improved performance if they are allowed to learn while moving around (Ellis et al., 2017). It has been reported that people in the military who do well in the classroom often perform poorly in the field, where they need quickly to switch from task to task in a stressful environment (Ellis et al., 2017). People with ADHD can outperform others in stressful, changing conditions that require a lot of physical activity.

There is 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 are more likely to develop ADHD with its serious behavioural complications if they experience low warmth in their relationships with their caregivers. They will be less likely than average children to develop these difficulties if they experience warm parenting. It is therefore too simplistic just to link genetic traits to outcomes: once again, there are significant gene–environmental interactions at play.

A serious ethical question to be asked is: should psychiatrists prescribe medication to help a child fit into an environment that is not ideal? Many ADHD services do not have behavioural support services to which they can refer. This puts pressure on psychiatrists to prescribe, even if 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 can be a conflict of interest between what is best for the child and what is easiest for teachers. In a rare study that examined the views of children with ADHD, Singh (2012) found that in both the UK and the USA, children wanted more treatment options apart from medication, but these were not available. The question of informed consent becomes difficult with younger children. Some of the complexities involved in assessment and treatment are illustrated by the case vignette in Box 15.2 (Swanepoel, 2021). (Both vignettes in this chapter are composite and fictionalised.)

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Box 15.2 Case vignette 1

Ethan (10) is placed with his grandparents under a special guardianship order as his mother is unable to look after him due to her dependence on drugs. Ethan was previously under a child protection plan due to neglect from his mother and physical abuse from her partner. His grandparents struggle to manage him and often think he is naughty and should be punished by not being allowed to go to football, which he loves. His school has referred him to Child and Adolescent Mental Health Services (CAMHS) as he is on the verge of exclusion: he is unable to sit still and concentrate and is constantly active. He also gets into fights with other children and is rude to teachers. One of his maternal cousins has recently been diagnosed with ADHD.

Ethan presents with clear symptoms of ADHD. He is constantly on edge and jumps at the slightest noise. When he explains his interactions with other children and teachers it is clear that he feels that he is defending himself and gives as good as he gets. He admits to having nightmares of the domestic abuse he witnessed and of the physical abuse he experienced. His greatest wish is to be returned to his mother's care to protect her. He believes this will happen if he is excluded from school, as he knows his grandparents won't be able to cope with him at home all of the time.

Care plan:

(1) Ethan is given a diagnosis of ADHD due to his long-standing symptoms of hyperactivity, impulsivity and inattention. He is started on the non-stimulant medication atomoxetine as he needs cover 24 hours a day and is unlikely to cope with the rebound effects of stimulants.
(2) Ethan is given a diagnosis of post-traumatic stress disorder due to his symptoms of hypervigilance and re-experiencing of the trauma (nightmares), and he is put forward for therapy with the aim of him feeling less threatened and less likely to respond to fear by fighting.
(3) His grandparents are referred to a parenting course for children with ADHD to help them understand him better. They are advised not to stop him from playing football as exercise is likely to help him be calmer at home.
(4) The social worker is informed. She arranges to meet Ethan to explain that if the placement with his grandparents fails he will go into foster care, as going back to his mum is not an option.
(5) A letter is written to the community mental health team looking after his mother to inform them of Ethan's diagnosis of ADHD, suggesting that she is screened as well, since untreated ADHD can be a factor in unmanageable substance abuse.

Follow-up at three months:

Ethan is much more settled at school and with his grandparents. Exclusion from school and placement breakdown have been avoided. He is happy to continue taking his medication.

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.

15.3 Autism Spectrum Disorder

15.3.1 Introduction

ASDs are a heterogeneous group of neurodevelopmental conditions. Those affected can range from profoundly intellectually disabled individuals who are non-verbal to high-functioning individuals who excel in their chosen profession. ASD is characterised by difficulties in social and emotional communication and restrictive and repetitive interests. The ability to maintain focus on a specific interest can be a real strength and can lead to high-functioning people with ASD outperforming neurologically typical ones.

However, it is important to note that most people with any one neurodevelopmental condition will also meet criteria for other neurodevelopmental conditions and that comorbidity is the norm rather than the exception.

The resemblance between some aspects of infant attachment disorganisation and behaviours typically found in neurodevelopmental disorders (such as freezing, atypical postures and behavioural stereotypies) was recognised by Main in her analysis of attachment styles in children diagnosed with autism (as discussed by Haltigan et al., 2021). There are now codified procedures to

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address this overlap, which are used when examining individuals with established neurodevelopmental disorders or who are at a high risk of these (Haltigan et al., 2021).

Autism exists on a spectrum – hence the increasing use of the term ASD. Unfortunately, early descriptions of these conditions suggested that they were the result of childhood psychoses or psychodynamic disturbances of parent–child relationships. This led to unhelpful and erroneous blaming of mothers. Advances in medical science helped to establish ASD as a neurobiological disorder of early brain development, the precise causes of which are still unclear. There are many genetic, epigenetic, metabolic, hormonal, immunological, neuroanatomical and neurophysiological aetiologies of ASD, as well as an array of gastrointestinal and other systemic comorbid disorders.

In line with the current understanding of gene–environment interactions, there is emerging evidence that maternal psychological distress may potentiate the effects of genes carrying a neurodevelopment risk via altered expression of regulatory genes in these networks prenatally (Breen et al., 2018). Thus, people with ASD form a heterogeneous population with extensive neurodiversity (Modabbernia et al., 2017).

15.3.2 Aetiology

We know that autism is a heritable neurodevelopmental disorder with deleterious effects on reproductive success. The combination of high heritability and low reproductive success raises the question: why was autism not eliminated by natural selection (Ploeger and Galis, 2011)? Autism risk genes do not seem to have evolved recently; they exhibit physical features related to their age, including large gene and protein sizes and regulatory sequences that help to control gene expression (Casanova et al., 2019).

It could be that autism is a 'disorder' or 'disease', and so is not adaptive, or that autism is an adaptation conferring some sort of selective advantage. The National Autistic Society (2021) gives a figure of 1% for the prevalence of ASD in the UK. In evolutionary terms, this is high for a condition that is reproductively disadvantageous. The prevalence of autism suggests that the second reason (that autism is an adaptation) plays a part, but this does not rule out the first (that autism is a disorder or disease).

It seems highly likely that autism is a disorder for those with single-mutation genetic changes and genetic syndromes. These individuals often have significant intellectual disabilities. Studies have found that at least 3–10% of cases of autism are related to *de novo* and rare genetic variants (De la Torre-Ubieta et al., 2016). Equally, environmental factors such as prenatal teratogens (e.g. valproate or alcohol) can cause syndromes that often classify as autism. Thurm et al. (2019) point out that autism accompanied by intellectual disability points towards the presence of a specific aetiological factor and cannot be classed as evolved or adaptive.

So-called high-functioning autism may, from an evolutionary perspective, be adaptive. We know that high-functioning autism is highly heritable and due to multiple genes that each have a small effect. A suite of studies has reported positive genetic correlations between the likelihood of developing autism and measures of enhanced mental ability (Crespi, 2016). These findings indicate that alleles for autism overlap broadly with alleles for high intelligence. Polimanti and Gelernter (2017: 4) state that 'using genome-wide data, we observed that common alleles associated with increased risk for ASD present a signature of positive selection in European populations. This strongly suggests that these variants have undergone positive selection during the course of human evolutionary history.'

ASD is sufficiently common that there may often have been one or two autistic individuals in each of our ancestral hunter-gatherer groups (which probably numbered 100–150 individuals). We know that ASD appears young, is lifelong and is more likely to appear in children born to older parents. High-functioning people with autism often show outstanding abilities in memory and spatial skills and develop expertise in their area of special interest. This may have been of survival value in traditional societies if food was sparse and solitary foraging increased the chances of survival (Reser, 2011). Ploeger and Galis (2011) hypothesise that, from an evolutionary point of view, men with well-developed systemising skills may have had an advantage. Systemising may have been important for developing tools and weapons and in hunting, tracking and trading. It is indeed the case that ASD seems to be more common in men than in women, though this may be at least partly due to misdiagnosis.

The suggestion that ASD has persisted because it was advantageous for ancestral hunter-gatherer

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tribes despite being deleterious for the individuals concerned is based on the theory of group selection. This proposes that traits may exist even if they are disadvantageous to the individuals themselves because they benefit the group in which the individual lives. This theory dates back to Darwin, but it fell into disfavour in the 1970s when it was widely presumed that the forces of natural selection operated much more strongly on individuals. More recently, however, there has been a resurgence in group selection theory (Wilson and Sober, 1994). Nowadays, the benefits of having people with high-functioning autism in quite a wide range of jobs are increasingly being appreciated.

Other evolutionary arguments for ASD have also been proposed. One such argument is connected with the fact that the genetic component of autism is polygenic, with at least 30 genes being involved. In most people, the interactions between these genes result in individuals with who are neurotypical or who have high-functioning ASD. Inevitably, however, in some individuals the result is 'the development of autism, low intelligence, or other pathologies' (Ploeger and Galis, 2011: 41). This argument sees autism as an unintended consequence of evolution – a bit like being substantially shorter or taller than is optimal as a result of the random assortment of chromosomes during gamete formation.

There is little doubt that over the course of our species' evolutionary history there has been selection for increased intelligence. Humans do not have the physical prowess of many other large mammals; we rely on our wits, including our social skills. However, it is worth pointing out that what is meant by 'intelligence' may not have been the same throughout our evolutionary history. Today's intelligence tests, for example, do not measure such important skills as persistence, truthfulness or reliability – all traits that may have been even more valuable when we lived in groups where everyone knew each other.

The case vignette in Box 15.3 illustrates what might be the consequences of a mismatch between a child with high-functioning ASD and their environment.

Box 15.3 Case vignette 2

Erin (12) presented to accident and emergency after a serious suicide attempt. She had a diagnosis of high-functioning ASD and attempted to end her life by hanging herself in her cupboard in the middle of the night in her room at her boarding school. Thankfully, the rail did not hold her weight, and the crash woke her roommate, who told the teachers.

Erin was highly gifted in music and was placed in a specialist residential school for this. However, she was uninterested in the social chit-chat of the other girls. She was seen as aloof and arrogant and was bullied. Erin did not have a close relationship with her high-performing parents and had no friends. When she became suicidal she did not tell anyone.

The outcome was that Erin was admitted to a psychiatric hospital and eventually placed in a specialist school for autistic children closer to home, which she attended daily. Care was taken to adapt the environment so as not to overwhelm her and to support her social skills as well as her musical gifts.

15.3.3 Development and Life History Theory

We know that mothering infants with autism (who are less likely to make eye contact and reciprocate a social smile) is more difficult (Shepherd et al., 2018). This results in a greater chance of psychiatric disorder in the mother (Fairthorne et al., 2016). In our recent evolutionary past, mothers needed to make difficult choices in order to raise at least some surviving offspring. We also know that infant characteristics play a role in maternal decisions in this respect. Hrdy and Burkart (2020) explain how, across traditional societies, mothers adjust parental investment in line with social and ecological circumstances. Those infants who are most skilled at appealing to their mothers and attracting other carers are most likely to survive. This must have led to selection pressure to smile, babble, develop theory of mind and engage in social interactions with others. Children with autism would have been at a disadvantage if they were born to mothers who did not have adequate social support. The pressures of natural selection may therefore have led to the consistent finding that most children with high-functioning autism are born to older fathers (Kong et al., 2012). An autistic child being born to older parents may well have been at an advantage because they were likely to be born with older siblings who would help them to get through their early years until

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their specific abilities were fully developed (Meilleur et al., 2015).

15.3.4 Complex Nature–Nurture Interactions

Many traumatised and neglected children show a range of developmental difficulties that can be confused with those of neurodevelopmental disorders such as ASD (DeJong, 2010; Oswald et al., 2010). This has led researchers such as Tarren-Sweeney (2010) to argue that these children do not access the correct services sufficiently because they are not well enough understood and to develop alternative ways of conceptualising the range of issues that such children have.

McCullough et al. (2014, 2016) researched looked-after children with a diagnosis of ASD. They were given a battery of tests including the Autistic Spectrum Quotient and tests of theory of mind abilities. On such measures there was no diagnosis of ASD. These children had all been maltreated and were typical in displaying 'sub-threshold' levels of behavioural difficulties, inattention, poor symbolic and imaginary capacities and basic levels of language skills, and they also struggled with peer relationships. Similarly, a large proportion of children adopted from Eastern European orphanages showed symptoms that were strikingly like autism (Rutter et al., 2007), including self-stimulating behaviours, rocking and an inability to manage change, as well as having limited verbal ability and little desire to be close to others, to seek comfort or to understand their own and others' emotions. Unlike ASD, these 'quasi'-autistic symptoms often improved when children were adopted into caring families, particularly if this happened when they were under two years of age.

We know that trauma and abuse can give rise to hypervigilance with accompanying strong amygdala activation, high cortisol levels and difficulties in concentrating that can seem rather like ADHD (Perry et al., 1995). Trauma often leads to high stress levels, a difficulty in focusing and concentrating, problems with executive functions and regulating emotions as well as interpersonal difficulties. Such children are easily over-aroused and can seem particularly ill-suited to the structured and ordered learning environment of the classroom or to chaotic playgrounds. Stimuli such as the loud voice of a teacher, the stare of a peer or the humiliation of not understanding something can quickly trigger disturbed behaviour. Such traumatised children can easily see threat where there is none, leading to an escalation of challenging behaviour. As a result, many maltreated children often are misdiagnosed as having ADHD or ASD (DeJong, 2010; Music, 2011). Evolved adaptive responses, such as being hyperactive in the face of danger or self-soothing by rocking in extreme neglect, can easily be misconstrued as an organic psychiatric disorder. On the other hand, it is important to acknowledge that children with neurodevelopmental conditions can also suffer trauma and that the presence of trauma does not invalidate the presence of a neurodevelopmental disorder or vice versa.

To complicate matters, some neurodevelopmental issues have their origins in prenatal life. For example, a high level of prenatal stress has a powerful effect on the developing foetus, at least partly due to cortisol crossing the placenta and affecting the hypothalamic–pituitary–adrenal axis of the unborn baby, programming it for stress postnatally and altering brain structure and functioning. Stressful adverse experiences such as maternal trauma are predictive of premature birth (Christiaens et al., 2015), which in turn is linked to many neurodevelopmental issues. Low-birthweight babies born to very anxious mothers are likely to have higher cortisol levels throughout their lifespan and a permanently altered stress response system. Severe antenatal stress affects levels of hormones such as dopamine and serotonin that regulate mood, and such stress has been increasingly linked to a range of childhood emotional and behavioural problems (Beijers et al., 2014) into adolescence and adulthood (Bosch et al., 2012). Such influences are independent of variables such as gender, parental educational level, smoking in pregnancy, birthweight and postnatal maternal anxiety. Such effects might themselves be seen as evolutionary adaptations. Sapolsky (2017), for example, suggests that the foetus primed for stress is more likely to survive in a stressful postnatal environment. It is as if the foetus is preparing for the life it is likely to live.

Prenatal factors that might not be evolutionarily adaptive include the effects of maternal use of alcohol and both legal drugs, such as antidepressants (Huybrechts et al., 2014) and antipsychotics (Kulkarni et al., 2014), and illegal

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drugs (Ross et al., 2015). Particularly pernicious is foetal alcohol syndrome (Mohammadzadeh and Farhat, 2014), with its devastating effects on many brain areas, including those central to memory and impulse control (Rangmar et al., 2015). Finally, nothing in our evolutionary history prepared us for the likelihood of premature foetuses surviving after being born as early as they sometimes are nowadays, and many premature babies show serious neurodevelopmental issues (Jarjour, 2015).

15.4 Conclusion

We maintain that an evolutionary perspective has much to contribute to debates about ADHD and ASD. Understanding these as biological variants that can have adaptive value for living in certain situations may help to shift perceptions of children from being 'naughty' or 'abnormal' to being seen as caught in an evolutionary mismatch. Behavioural strategies in school, for example, could then focus on allowing plenty of physical activity for children with ADHD and providing for the special skills of those with ASD. Longer term, we may need to rethink how schools are conceptualised and run. For people with ADHD and ASD, an evolutionary perspective might also help them to understand their strengths and to seek occupations where these are valued. There will inevitably be downsides to these conditions, as there probably are for all human temperaments. However, reframing such conditions in evolutionary terms paves the way for a more informed discussion of the complexities of their aetiology, diagnosis and treatment and of our ethical and social responsibilities towards the people in these groups.

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