Autistic Spectrum Disorder in Prehistory

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Individuals with 'extraordinary' or 'different' minds have been suggested to be central to invention and the spread of new ideas in prehistory, shaping modern human behaviour and conferring an evolutionary advantage at population level. In this article the potential for neuropsychiatric conditions such as autistic spectrum disorders to provide this difference is explored, and the ability of the archaeological record to provide evidence of human behaviour is discussed. Specific reference is made to recent advances in the genetics of these conditions, which suggest that neuropsychiatric disorders represent a non-advantageous, pathological extreme of the human mind and are likely a by-product rather than a cause of human cognitive evolution.

It has been suggested that individuals with 'extraordinary' minds (such as those suffering from neuropsychiatric conditions including autistic spectrum disorders and schizophrenia) have made a disproportionate contribution to mankind's social, cultural and cognitive development. For example, schizophrenia has been variously linked to leadership qualities, creativity and musical ability (Ellenberger 1970; Horrobin 2001; Polimeni & Reiss 2002 and see Polimeni & Reiss 2003 for review) — according to Horrobin (1998) it is precisely these characteristics and schizophrenic disorders that have made us human. Furthermore, shamanism has frequently been described as a culture-specific form of schizophrenia or psychosis (Silverman 1967; Polimeni & Reiss 2002; El-Mallakha 2006).

The emergence of fully modern human behaviour has been linked to the development of social mechanisms that integrate individual cognitive variation or 'differences of mind' (Spikins 2009). Within this model (which uses autistic spectrum disorders as an example of different minds), it has been proposed that inclusion and exploitation of extraordinary differences of mind confers a selective advantage at the 'society' or population level.

This model has its basis in Darwinian evolutionary theory — beneficial 'differences' are a prerequisite substrate for natural selection and become more prevalent over time. The result is a 'spectrum of minds'. An individual's position on this spectrum determines the likelihood that they will make an extraordinary contribution to society. However, extraordinary minds or different minds models raise a number of issues:

- the potential societal benefits of neuropsychiatric disorders;
- the extent of prehistoric tolerance and integration;
- the nature of the genetic inheritance of neuropsychiatric disorders;
- the threshold between 'neurotypic' and 'extraordinary' minds.

In this article it is proposed that although the evolutionary development of humans can be correlated with the emergence of neuropsychiatric disorders, these conditions were a deleterious by-product of this evolution rather than part of the causative mechanism. This will be explored with specific reference to autistic spectrum disorder (ASD), a modern clinical classification that encompasses *both* Asperger Syndrome and autism.

The potential societal benefits of ASD

Autistic spectrum disorder encompasses a group of conditions with varying degrees of severity, ranging from Asperger Syndrome to autism. Autism is considered one of the most severe childhood psychiatric disorders resulting in impairment of verbal and non-verbal communication, abnormality of imagination, and failure to develop normal social relationships (Baron-Cohen *et al*. 1985; 1998). Associated symptoms include mental retardation, insistence on sameness,

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repetitive movements, and 'islets of ability' or 'splinter skills' (Ritvo & Freeman 1977; Baron-Cohen *et al*. 1985). Individuals with Asperger Syndrome meet the criteria for autism but with no impairment of language or general cognitive development (Craig & Baron-Cohen 1999). The reported prevalence of ASD in modern populations ranges from approximately 1 in 300 births (Fombonne 2003) to greater than 1 in 70 births (Baron-Cohen *et al*. 2009). By comparison autism is a relatively uncommon condition affecting 1 in 2000 to 1 in 2500 births (Baron-Cohen *et al*. 1985; Ehlers & Gillberg 1993).

It has been suggested that individuals with Asperger Syndrome or 'high-functioning autism' may have played a role in small-scale societies — potentially acting as a 'hub' for the spread of new ideas, inventions and different ways of thought (Trehin 2003; Spikins 2009, 186). Polimeni and Reiss (2002; 2003) also suggested that certain traits common to many neuropsychiatric conditions may have provided specializations beneficial at the population level. Useful qualities are defined as obsessive behaviours (Polimeni & Reiss 2002), rigid analytical thinking, exceptional memory and attention to detail (Spikins 2009). These characteristics are suggested to be particularly advantageous in the production and development of prehistoric technology. Increased standardization and efficiency in blade and microblade industries, the use of new materials and the production of more complex technologies, the emergence of systems of notation, and the rapid rate of innovations have been identified as archaeological correlates of such behaviour, and thus potential evidence for the influence of the autistic mind on modern human development (Spikins 2009).

However, these beneficial characteristics are also exhibited by neurotypical minds — they are not exclusive to ASD. Conversely, inflexibility in thinking, difficulty with planning and organization, and adherence to routine, which could be considered the antithesis of extraordinary thought, are actually diagnostic characteristics of ASD (Ozonoff & Jensen 1999; Jankowiak 2005).

Interpretation of cognitive form from the archaeological record is naturally open to debate. Images executed in Palaeolithic cave art have been described as exhibiting similarities to those produced by 'savants' with ASD (Humphrey 1998) — supporting evidence, in the view of Kellman (1998) and Haworth (2006), that Upper Palaeolithic *Homo sapiens* may not have shared the same cognitive traits or language capabilities as humans today. Trehin (2003) proposes an alternative explanation: similarities are observed between images portrayed in Upper Palaeolithic parietal art and those produced by some autistic individuals with splinter skills because autistic individuals were responsible for creating these Ice Age works of art. Autistic savants may be talented artists, skilled in the execution of real-life objects (Baron-Cohen 1999); however, commonalities between Ice Age parietal art and that of modern autistics are not all-encompassing. The use of colour, which is a striking feature of some Upper Palaeolithic parietal art, is unusual in art produced by individuals with ASD (Kellman 1998). The suggestion that individuals with autism were responsible for, or influential in, the development of art is further complicated by the evidence for symbolic or 'invented' motifs found in Palaeolithic art (Spikins 2009). Baron-Cohen (1999) notes that the invented figures represented in parietal and mobiliary art are suggestive of a 'theory of mind' (see Premack & Woodruff 1978) among Upper Palaeolithic artists. Theory of mind (ToM), the ability to attribute varying states of mind to self and others, is notably lacking in individuals with autism and Asperger Syndrome (Baron-Cohen 1999).

Spikins (2009) suggested that the attention to detail and recall evident in some Upper Palaeolithic art need not indicate the contribution of the autistic mind but rather that individuals with Asperger Syndrome may have been influential in the production of Upper Palaeolithic art. However, it is widely accepted that generally creativity is reduced in individuals with ASD (Craig & Baron-Cohen 1999). In particular, imaginative creativity is impoverished, even in high-functioning individuals with Asperger Syndrome (Frith 1972; Craig & Baron-Cohen 1999; Turner 1999). Although studies have demonstrated that ASD children with language development equivalent to a 2½-year-old can be taught to play creatively (Stahmer 1995) this requires considerable input from skilled therapists and such maximization of the potential creativity of individuals with ASD is unlikely to have occurred in a prehistoric context in the absence of support. Thus, it seems unlikely that individuals with autistic spectrum conditions would have made a major contribution to the inception and proliferation of Palaeolithic art. Alternative explanations for its representational style, for example the effects of psychotropic drugs on the 'normal' mind, are also viable. Under such conditions the normal mind may enter an altered cognitive state that can result in the accomplishment of 'savant-like images' (Humphrey 2002).

Autistic traits and different minds have also been described as beneficial to economic success in prehistoric societies. For example, it has been suggested that unique understanding of natural systems such as the movement of animals or the weather might be attributed, either directly or by influence, to

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autistic thinking (Spikins 2009). Although individuals with ASD may demonstrate exceptional skills in rote memory this is associated with an inability to process information at the global level, i.e. a failure to see the whole picture (Shah & Frith 1993). Additionally, the exceptional ability to memorize is restricted to certain types of information, particularly 'unrelated stimuli' (Shah & Frith 1993). Individuals with ASD demonstrate deficits in memorizing sentences, related items and detecting patterns (Hermelin & O'Connor 1967; Frith 1970; Tager-Flusberg 1991; Frith & Happé 1995).

Individuals with 'splinter skills' tend to focus on one aspect of the world around them which fulfils their requirements for order and process. That aspect is highly likely to be culturally guided — in Western society today this can range from a focus on timetables, mathematical problem-solving, to naming the day corresponding to a birth-date (Folstein & Rosen-Sheidley 2001; Thioux *et al.* 2006). The focus does not represent an inventive step, merely the honing of very specialized skills. Moreover, it may be that the modern, regulated, technological, data-driven world is ideal for maximizing the potential of the autistic individual (Baron-Cohen 2000, 497).

Prehistoric concepts of tolerance and integration

Whilst we accept that extraordinary minds may have made a disproportionate contribution to cultural development in human prehistory, if autistic and autistic spectrum minds are to be successfully argued as a key example of difference of mind that 'played a singularly important role' (Spikins 2009, 191) in the emergence of fully modern human behaviour, then two criteria are essential: (i) the archaeological record must reflect the societal capacity to integrate radically different minds, and (ii) artefact types, interpreted as evidence for the integration of autistic thinking, could not have been the product of neurotypical minds.

Spikins (2009) suggested that symbolism (in the form of personal adornments, burial ritual and the use of red ochre), long-distance communication, social rituals, organized use of space, and mechanisms to counteract dominance signal the emergence of 'social mechanisms for integration' from *c.* 160,000 years ago. The subsequent benefits of this integration were suggested to include: the development of new or more efficient, standardized or complex technology, more efficient exploitation patterns and use of new ecological niches (see Spikins 2009, table 5 for the full list of suggested benefits).

However, it is difficult to identify particular and complex social and cognitive changes from the archaeological record and then make the clear and necessary distinction between the sequential integration and benefit phases of this proposed process. It could be argued that the increasing use of personal adornment to signify emotional ties and affiliations was a mechanism for emphasizing exclusion or 'otherness'.

Moreover, a number of the supposed benefits of integrating different minds appear in the archaeological record some time prior to the emergence of biologically modern humans or even among non-*sapiens* hominins. For example, several distinct lines of evidence imply the use of aquatic resources by pre-*sapiens* hominins. Clam shells were used as tools for butchering large mammals at Sangiran, Indonesia, *c.* 1.6–1.5 million years ago (Choi & Driwantoro 2007). Lower Palaeolithic seafaring inferred from the presence of stone tools on Flores Island, Indonesia (Bednarik 2003) suggests that early hominins would also have been familiar with maritime resources. Shellfish, fish and/or sea mammal remains have been recovered at numerous pre- and/or non-*sapiens* sites (e.g. Wymer 1982; Stewart 1989; 1994; Stiner 1993; Cleyet-Merle & Madelaine 1995; Barton 2000; Stringer *et al.* 2008; Zilhão *et al.* 2010) and may have provided the essential nutrients required to support increased encephalization in *Homo* spp. in general (Leigh Broadhurst *et al.* 1998) and in *Homo sapiens* in particular (Crawford *et al.* 2000). It is likely that changing sea level has obscured archaeological understanding of the full extent to which hominin populations exploited marine resources.

Arguably, composite tools were used in the pursuit of large mammals in Middle Pleistocene Europe (see d'Errico 2003 for a review). Furthermore, long-distance movement of raw materials over hundreds of kilometres is evident in the Mousterian of central and south-central France (Slimak & Giraud 2007).

D'Errico (2003, 190) has observed that many of the archaeological 'signatures' of behavioural modernity identified by McBrearty and Brooks (2000) are manifest in the material culture of European Middle Palaeolithic populations, and thus are of little heuristic value. The use of personal adornments and mineral pigments by Neanderthal groups highlights the difficulty of linking *sapiens*-specific cognitive traits to artefact types. Often, evidence for creativity and the use of symbolic items by Neanderthals has been dismissed as 'acculturation' or imitation (e.g. White 2001; Mellars 2005; 2010). However, finds of shell adornments and the use of red and yellow pigments at the Spanish sites of Cueva de los Aviones and Cueva Antón calls this into question (Zilhão *et al.* 2010). Significantly, both sites date to *c.* 50,000 BP millennia before the appearance of anatomically modern humans in this region.

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Zilhão *et al.* (2010) concluded that cognitive-genetic explanations for the appearance and use of personal adornments and pigments are inadequate.

Altruistic behaviour and the care of physically incapacitated members of society have been inferred from the pre-*sapiens* fossil record (see Hublin 2009 for review). Although such evidence is controversial, and alternative interpretations have substance (Hublin 2009, 6429), it has been observed that chimpanzees likely exhibit altruism that extends beyond survival of offspring and kin (Hublin 2009). Altruism, and potentially inclusivity, may not, therefore, be *sapiens*- or even hominin-specific traits. However, if (and this is debatable) the appearance of personal adornment reflects the emergence of more clearly defined social ties/alliances and the integration of different minds from *c.* 160,000 years ago, this does not necessarily imply that ASD differences of mind were being exploited to confer a selective advantage at the individual or population level. We must be cautious in the assumption that prehistoric societies would be able to support the additional needs of the ASD individual in particular to the extent that they could 'exploit' their 'autistic talents' (cf. Spikins 2009, 193). Present-day medical care and educational provision are designed to maximize the potential of the individual diagnosed with ASD (see Matson *et al.* 1996 and Goldstein 2002 for reviews). It is questionable whether the same ability to realize the full potential of each individual would have been possible in prehistory.

In certain traditional societies social relations are of greater importance than consideration of individual states of mind (Lillard 1997). In such environments ASD could be viewed as non-advantageous (cf. Baron-Cohen 2000, 497). Social competence is reduced in individuals with deficits in ToM (Brüne 2006). Poor non-verbal communication and an inability to predict the behaviour of others are characteristics of both autism and Asperger Syndrome (Baron-Cohen *et al*. 1999). These might restrict the social role of individuals with ASD in traditional societies. The inability of those with autism to regulate behaviour through inhibition (Turner 1999) in conjunction with limited verbal skills might result in social exclusion, particularly in sporadic cases of ASD where behaviour is poorly understood or unfamiliar to other members of the family group or society at large. Focused or directed aggression, which is arguably a useful trait in certain social situations, for example when negotiating with belligerent neighbours, is not a common feature of Asperger Syndrome (Ghaziuddin *et al.* 1991). Moreover, inadequate comprehension of non-verbal cues (Scott 1985) in individuals with Asperger Syndrome might further hamper social roles.

Mode of genetic transmission: ASD genetics and potential evolutionary pressures

The central question is whether the hypothesized benefits or situational success (Spikins 2009) of an ASD mind are responsible for the selection and maintenance of the genetic factors that predispose toward these conditions. This would imply that the disease is the evolutionary beneficial state, increasing the likelihood of reproduction and passing on the genetic predisposition factors to the next generation.

The details of the transmission of genetic predisposition to ASD have recently been clarified and provide a basis for determining the validity of this hypothesis (Freitag *et al.* 2010). Firstly, it is clear from twin and family studies that there is a substantial genetic contribution to autism, even though many of the instances of the condition are apparently sporadic (i.e. without evidence of a family history). This apparent discrepancy can be explained by the fact that ASD is a complex genetic condition resulting from the interplay of many genes and many different forms and strengths of genetic mutation within those genes. For example, large, genome-wide association studies suggest there are a number of small-effect but common genetic susceptibility variants (termed single nucleotide polymorphisms) for autism (e.g. Zhao *et al.* 2007). The number and combination of these within an individual dictate whether they will go on to exhibit the sporadic form of ASD. Additionally, data from cytogenetic, copy number variation (deletions or duplications in the genomic DNA sequence) and linkage studies suggest there is an alternative genetic mechanism that tends to be rarer but stronger in effect (higher 'penetrance') (Zhao *et al.* 2007). Because of the stronger effect of these latter genetic risk factors they tend to be observed as inherited traits running in families — albeit with variable expression on the Asperger/autism scale. In such high-risk families the rate of inheritance is 50 per cent in male children (Zhao *et al.* 2007). Additionally, copy number variants can also appear *de novo* in individuals — i.e. they appear sporadically in the first carrier but show familial inheritance in subsequent generations. This observation is particularly important because *de novo* instances of genetic ASD indicate that the prevalence of ASD is likely to be fairly constant moving back through history and into prehistory. Perhaps where there is inheritance of traits, there might have been some form of support structure enabling the individual with ASD to be fully included in society.

As well as discussions of the potential benefits of ASD gene variants in prehistoric societies, there is also an expanding literature on the genetic causes

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and consequences of the emergence of modern human cognition (Vallender *et al*. 2008). Spikins (2009) suggested that the manifestation of ASD with its associated genetic underpinnings might have made a significant contribution to the evolution of the modern mind. Most genetic studies point to the emergence and establishment of *Homo sapiens* as the stage when evolutionary processes responsible for increased brain function (cognition) were most rapid (McHenry 1994; Enard *et al.* 2002; Caceres 2003; Vallender *et al.* 2008). This is manifest as a set of genes involved in brain development and function that bear the hallmarks of evolutionary action. In fact, these genes show a greater overlap with schizophrenia risk genes than those associated with ASD. *In other words, ASD is likely a consequence of modern human cognition rather than an integral part of its formation.*

Threshold genetics: too much of a good thing

It has been suggested that conditions like ASD and schizophrenia arose as a consequence of the rapid evolution of the human brain (Crow 1997; 2000; Randall 1998). As such, neuropsychiatric conditions may be an unfortunate side effect of the massive cognitive development that distinguishes humans from other primates (Crow 2000). The higher brain functions that provide humans with the advantageous cognitive, behavioural and social skills, enabling them to adapt to particular environmental and social pressures, are the very same functions that malfunction in neuropsychiatric disorders. In this way, there is an overlap in the gene variants that have been positively selected as advantageous in this capacity and the set of genes that have been linked to psychiatric disorders. Studies have demonstrated just such a link between human evolution and the positive selection of mental illness genes (Crespi *et al.* 2007).

This observation can provide a mechanistic grounding to explain why the common, small-effect, ASD predisposing gene variants have remained at appreciable frequencies in the population (rather than disappearing through negative selection pressure). Rather than being harmful, the predisposing variants may individually have beneficial qualities (Crespi *et al.* 2007), only becoming harmful when many are inherited simultaneously.

Therefore a 'happy medium' model applies with such genetic variation. The tweaking of brain function by the accumulation and selection of particular genetic variants in the human population overall seems clear cut. However, if we consider the fact that the segregation of these variants is random, then some individuals will be carriers for just a few, whereas others will possess many. There would exist a threshold beyond which too many of such gene variants carried by one individual would push that individual from a healthy (and advantaged) state into a pathological disease state. Therefore, the question becomes one of where precisely the threshold between positive and harmful effects lies. The advantage only exists when the variants are present in a sub-threshold quantity and not when they result in disease pathology. The relatively low frequency of sporadic ASD in the population adds weight to the argument that it is a disease condition resulting from an infrequent constellation of genetic influences rather than being a successful difference of mind in evolutionary terms.

This argument is strengthened by considering *de novo* copy number variants leading to ASD (Sebat *et al*. 2007); they have a pathological mutational mechanism through the loss or gain of genes, which are naïve to any influence of evolutionary selection, and yet they have clinical features indistinguishable from those individuals who have ASD through the accumulated genetic variation model described above. Thus a clearly pathological process produces a condition identical to that which some propose to be a source of benefit.

Differences in mind occur at the population level. However, the majority can be classified within a broadly defined norm. Therefore, contributory people in society, in terms of innovation, invention and creativity, need not necessarily be outside of this norm despite the recent attention given to the relationship between neuropsychiatric conditions and extraordinary contribution to, or status in, society. For example, some have attempted to shoehorn a diagnosis of schizophrenia on certain cultural archetypes such as shamans (e.g. Demerath 1942; Silverman 1967; Scheff 1970). However several authors propose that shamanic states of consciousness have also been over-pathologized. Noll (1983) and Walsh (1993) stipulate that shamanic states of consciousness are not equivalent to schizophrenic conditions, while Stephen and Suryani (2000) argue that the role of the initiatory crisis has been overplayed in Western accounts of Balinese shamanism. Moreover Crow (1997; 2000) has presented a convincing case for schizophrenia as a disadvantageous by-product of the evolution of language.

Similarly, many prominent historical figures described as geniuses in their particular field have been posthumously diagnosed as having ASD (Lyons & Fitzgerald 2005; Walker & Fitzgerald 2006) or, alternatively, schizoid tendencies (Horrobin 2001). The inference from such diagnoses is that the contribution of autistic and other extraordinary, and specifically male, minds to technology in particular, and to wider society in general, has been very significant (e.g. Fitzgerald 2004).

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However, it is likely that genius has also been over-pathologized in such revisionist studies (Sacks 2004). Sacks's studies of the lifestyle and behaviour of Einstein, Wittgenstein and Newton led him to the conclusion that they were unlikely to have suffered from ASD (Sacks 2001; 2004). The many and varied diagnoses of Van Gogh's illness (see Blumer 2002 for a review) highlight the difficulty of attributing neuropsychiatric conditions retrospectively. In similar vein, Kellman (1998) noted that gifted artists with autism are no more common than gifted artists with 'normal' minds.

Conclusions

Although it is possible that there was a change in behaviour that resulted in the inclusion of different minds within society from *c.* 160,000 years ago, the archaeological and fossil evidence to support such an assertion remains contentious. It is perhaps premature to assume that the talents or splinter skills of individuals with ASD could be exploited by prehistoric societies in such a way that those skills would confer a population-level advantage.

While it is straightforward to integrate differences of mind and their advantageous by-products into the evolution of modern human cognition, it is unlikely that social changes that resulted in acts of integration and 'exploitation' of individuals with ASD or other neuropsychiatric conditions led to, or were a principal component of, the emergence of fully modern behaviour in humans. There is a complex genetic component to fully modern human cognition and behaviour which was/is vital for the success of *Homo sapiens*. However, this produces a normal distribution of benefit with autistic spectrum disorders and other neuropsychiatric conditions representing the pathological manifestation of the extremes of genetic permutation occurring in the population gene pool.

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