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Original Study

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How Do We Explain 'Autistic Traits' in European Upper Palaeolithic Art?

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Abstract: Traits in Upper Palaeolithic art which are also seen in the work of talented artists with autism, including most obviously an exceptional realism, remain to be explained. However any association between the famously evocative animal depictions created in the European Upper Palaeolithic and what is commonly seen as a 'disorder' has always been contentious. Debate over these similarities has been heated, with explanations ranging from famous works of Upper Palaeolithic art having been created by individuals with autism spectrum conditions, to being influenced by such individuals, to being a product of the use of psychotropic drugs. Here we argue that 'autistic traits' in art, such as extreme realism, have been created by individuals with a cognitive extreme of local processing bias, or detail focus. The significance of local processing bias, which is found both as a feature of autism spectrum conditions and in artists with exceptional talent at realistic depiction who aren't autistic, has implications for our understanding of Upper Palaeolithic society in general, as well as of the roles played by individuals with autism spectrum conditions.

Keywords: Upper Palaeolithic, Ice Age, prehistoric art, autism, autism spectrum condition, talent, local processing bias, exceptional realism, social influence

1 Introduction: 'Autistic Traits' and European Upper Palaeolithic Art

A long standing debate about the existence of 'autistic traits' in European Upper Palaeolithic art developed following observations by Humphrey (1998) that several key features seen in such art were also seen in the art of talented individuals with autism.

Humphrey (1998) based his observations on comparisons with the work of Nadia, a talented non-verbal child with autism. He pointed out that Nadia's exceptionally talented drawings shared with European Upper Palaeolithic parietal art *a focus on components rather than whole forms*, *superimposition of forms* and *remarkably detailed and accurate visual depiction of animals from memory*. Other research independently came to same conclusions when Kellman (1998) compared ice age art (specifically at Chauvet Cave) with the art of a precocious autistic artist, in this case Jamie, aged 7. Kellman similarly recognised many similar features between Jamie's art and that in the European Upper Palaeolithic–not only an *outstanding observational skill*, but also use of *perspective*, *foreshortening* and a *primary concern with vigorous outline to which colour and hue are secondary*.

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The explanation for such similarities remained elusive. Humphrey speculated that similarities might have arisen through the cognitive effects of a shared lack of symbolic categories or words for things between non-verbal individuals with autism and people in the Upper Palaeolithic, a position hotly contested in responses (1998). Kellman attributed the similarities not to language but to common *ways of seeing* which remained to be fully understood (1998). Others suggested that individuals with autism spectrum conditions (ASC) themselves might have played some role in Upper Palaeolithic art. Trehin later attributed a key creative impetus for Upper Palaeolithic art in the creativity seen in talented artists with autism (Tréhin, 2003). Spikins however suggested there was some influence of autism on Upper Palaeolithic art (Spikins, 2009), with talented individuals with autism potentially influencing other artists (Spikins & Wright, 2016).

The debate over such traits became heated. Humphrey amended his perspective to suggest that psychotropic drugs may play a role in the similarities (Humphrey, 2002) and forceful counter-arguments to the idea of any involvement of individuals with autism in Upper Palaeolithic art were put forward by Pickard et al. (2011) and Bednarik (2013, 2016). Pickard and colleagues argued that autism is a disorder, associated with social deficits which would prevent individuals from making such a contribution without modern medical and educational support. When such individuals sporadically appeared they would not benefit from the kinds of support needed to allow them to be influential or make a contribution. Bednarik (2013) added that any incorporation of vulnerable members of society occurred too late to have influenced Palaeolithic art, stating the individuals with autism would not have been socially tolerated or genetically included in palaeolithic societies, and their involvement was therefore a 'fairy tale' (Bednarik, 2016). Pickard et al. (2011) ascribed the autistic traits seen in Upper Palaeolithic art to the influence of psychotropic drugs, whilst Bednarik (2013) ascribed the same traits to sensory deprivation and trance.

There are of course certain *differences* between European Upper Palaeolithic art and that of talented individuals with autism. Most notably there are differences in perspective, with talented autistic artists usually displaying foreshortening and Upper Palaeolithic animals typically shown with twisted perspective (i.e. a side view with elements such as ears and horns show partly from the front). Comparisons have also yet to be made to reveal similarities or differences in the sequences of production (as demonstrated by Fritz and Tomasello 2000; 2007 for Upper Palaeolithic art at Chauvet cave for example).Nonetheless explanations for the notable *similarities* between the famous depictions in Upper Palaeolithic art and those of exceptionally talented artists with autism–that such art shows an understanding of perspective and foreshortening, a superimposition of forms, a focus on parts of forms and above all an *exceptional realism* (see example of lions from Chauvet Cave figure 1)–remain to be fully understood. Explanations remain hotly contested. Kellman (1998) and Humphrey (1998) focus their attention on similar perceptual or cognitive systems as potential explanations, Spikins (2009) focuses on a cultural influence of autism spectrum conditions, and Pickard et al. (2011) , Bednarik (2013) and latterly Humphrey (2002) focus on altered states of consciousness through sensory deprivation or psychotropic drugs influencing artistic skills.

2 A New Interpretation

Here we argue that drug use cannot explain autistic traits in European Upper Palaeolithic art, and moreover individuals with autism spectrum conditions (ASC) were present and playing a role in Upper Palaeolithic societies. However, rather than individuals with ASC *per se*, we argue that individuals with a cognitive bias towards perceiving fine detail, those with extreme *local processing bias*, are key to the exceptionally talented realistic depiction and other 'autistic traits' seen in some of the most well known Upper Palaeolithic art. Local processing bias is common in autism but also seen in individuals without autism, with its influence also seen in other material culture of the period.

Figure 1. The frieze of lions at Chauvet Cave shows traits in common with the art of exceptionally talented individuals with autism, including exceptional realism, precise detail, a focus on parts rather than wholes and overlapping forms. Source: https://commons.wikimedia.org/wiki/File:Lions_painting,_Chauvet_Cave_(museum_replica).jpg

2.1 Psychotropic Drugs, Autistic Traits and Exceptional Realism in Art

It is certainly tempting to believe that we all have a latent talent at art which could be revealed through drug use. Psychotropic drugs, altered states of consciousness and even brain damage certainly change our sensory experience and how we think and act. Moreover it is entirely reasonable to suggest that societies in the Palaeolithic *may* have used psychotropic drugs. Drug use is commonly reported ethnographically in hunter-gatherer contexts and moreover Guerra-Doce uses archaeological evidence to argue for widespread evidence of drug use in prehistoric societies post 8,000bp (2015). Even without drugs societies in the Palaeolithic may have attained altered states of consciousness through trance or sensory deprivation in ways that might affect their depictions.

Crucially however whilst drugs and changes to the brain can affect *artistic production* and *influence novel ideas* they do not increase *capacities for realistic depiction*.

Psychedelic drugs, such as LSD and mescalin for example, have attracted attention as being associated with changes in *creativity*. Psychedelic drugs do change sensory experience, and create changes in emotions and an expansion of an individual's sense of thought and identity (Sessa, 2008; Schartner et al., 2017). Some of the largest studies were carried out in the late 1950s and 1960s for example. The largest study was one in which LSD sessions were facilitated for almost 1000 people between ages 18 and 81 in a long term series of experiments between 1954 and 1962, in which artistic output was recorded (De Rios & Janiger, 2003). Artistic output was affected by the drug taking, becoming more expressionistic, and showing a sharpening of colour and greater freedom from accepted norms. Significantly however no improvement in realism or accuracy in depiction has ever been recorded in this or other studies (e.g. see Janiger & De Rios, 1989). Psychedelic drugs can change the nature of artistic output but in ways that move away from, rather than towards, exceptional realism.

Other promising contenders for drugs which might affect artistic production are dopaminergic drugs, such as those used to treat Parkinson's disease. There *have* been anecdotal accounts of individuals expressing artist talents after taking these (Zaidel, 2015) and such cases might *appear* to suggest that drugs can release artistic talent. Dopaminergic drugs and in certain cases brain damage (such as dementia) can have a disinhibitory effect, which increases risk taking across different domains, such as overspending, compulsive sexual thoughts and feelings and gambling and it isn't unusual for individuals to be motivated to produce art as part of this disinhibitory process. However these individuals overall show no particular talent (Canesi et al., 2012). The very rare cases of 'de novo' exceptional talent in realistic depiction appearing following drug use are at the levels of latent talent we would expect in a general population some of whom possessed a talent they had been inhibited from expressing (Zaidel, 2015). As with 'de novo' compulsive singing caused by dopaminergic drugs (Bonvin et al., 2007), whether this increased 'creative output' stimulated by such drugs is pleasant and aesthetically pleasing is a product of the existing talent *before* the effect of drugs not the drugs themselves.

Drugs may influence motivations, and spur artistic production, however they do not make us talented artists (except perhaps in our own estimation). Zaidel comments:

> '*Obviously, artistic talent has to be in place to begin with, or else no amount of disinhibition, frontal lobe damage, or neurotransmitter imbalance would help artistically*.' (Zaidel, 2014, p. 5).

2.2 The Presence of Individuals with Autism in Upper Palaeolithic Societies

Recent evidence has also demonstrated that individuals with autism *were* present in the European Upper Palaeolithic. Autism is not, as is often assumed, a recent phenomenon as the genes coding for autism have a long ancestry, dating to before the emergence of the hominin line. Autism is thus part of the shared ape genome (Marques-Bonet & Eichler, 2009; Dumas et al., 2012) with autistic traits apparent in chimpanzees (Marrus et al., 2011; Faughn et al., 2015) and autism genes also found in other primates including macaques (Yoshida et al., 2016). These genes play a role in the 'evolvability' or capacity to adapt of the ape and human genome (Gualtieri, 2014). Whist the genetics of autism are complex, and over 1000 genes are involved in the risk of ASC (Liu et al., 2014), autism is found cross-culturally at similar rates (around 1–4% of the population) (Wakabayashi et al., 2007) and autism runs in families (52.4% heritability) (Baron-Cohen et al., 1998; Gaugler et al., 2014; Huguet et al., 2016). Whilst we often perceive autism spectrum conditions to be a 'disorder' they are best seen as an extreme of personality variation (Robinson et al., 2016).

The genetics of autism have been subject to certain misunderstandings. Pickard et al. (2011) describe autism as *only* occurring spontaneously or 'de novo' in palaeolithic populations and being necessarily highly disabling. Autism can appear spontaneously and such cases are typically associated with autism with intellectual impairment and the most severe disability. However essentially autism *with* and *without* intellectual disability are caused by separate genetic mechanisms, with the former being less prevalent. This more 'severe' form of autism is caused by de novo mutations and CNVs (copy number variation) which may become inherited but only account for approximately 5% of the heritability of autism and 30% of diagnoses. In contrast to the conclusion presented by Pickard et.al (2011) most cases of autism spectrum conditions (about 70%) occur through inherited genetics and are typically cases without intellectual impairment, previously often termed Asperger Syndrome (Iossifov et al., 2014; Ronemus et al., 2014). Autism without intellectual disability is coded by common variants called single nucleotide polymorphisms (SNPs) that have been shown to be under positive selection and are not necessarily disabling (Warrier et al., 2016; Polimanti & Gelernter, 2017). Potentially thousands of SNPs that increase risk are scattered throughout the genome, which are thought to act additively (Klei et al., 2012). They also account for an estimated 95% of the heritable aspect of ASC (Gaugler et al., 2014; Huguet et al., 2016).

The fact of positive selection of autism without intellectual disability (which is not necessarily disabling) suggests that these genes bring advantages, leading to survival and procreation. Whilst there are those who suggest this positive selection would not have been present in the paleolithic, there are a number of arguments to suggest that it would. Firstly, the genetic evidence confirms that individuals with autism *were* present in the Palaeolithic. Secondly evidence is growing that some advantageous elements related to genes associated with autism have been subject to positive selection (Warrier et al., 2016; Polimanti & Gelernter, 2017). Thirdly the phenotypes of those who have autism spectrum conditions without intellectual disability carry a number of strengths including significant perceptual abilities and special skills (Meilleur et al., 2015) improved concentration, ability to recognise patterns, and strong factual memory (Lorenz & Heinitz, 2014) all likely to be of benefit in Upper Paleolithic environments (Spikins, Wright & Hodgson, 2015). Lastly, the final piece of the jigsaw is that the community they live in needs to value them and it is precisely this time in history where Thorpe (2016) argues that the presence of empathic behaviour and caring should be treated in the light of current evidence as the null hypothesis. Archaeological interpretations can no longer discount the influence of individuals with ASC in past societies. Indeed Spikins et al. (2016) have argued for example that the incorporation of autism is explained through understanding that autism spectrum conditions are not asocial, but *differently social*, with individuals with autism without intellectual impairment potentially bringing important skills and fulfilling important roles in society in the past, as in the present.

Does this mean that talented individuals with ASC created some of the most exceptional depictions in European Upper Palaeolithic art? Not necessarily. Exceptional precocious talent in realistic depiction, associated with other traits such as focus on detail or overlapping forms, is also, rarely, seen outside of autism. ‘Autistic traits’ are thus something of a misnomer, with their explanation rightly lying beyond an extreme focus on ASC themselves.

Our closer consideration of the cognitive factors behind exceptional realism and other traits of autism such as overlapping forms and precise detail, alongside our detailed large scale population survey, suggests that the explanation for ‘autistic traits’ in Upper Palaeolithic art lies in *local processing bias* (and detail-focus). Local processing bias is a cognitive bias which is very common in ASC, but also present in some individuals without the condition.

3 The Cognitive Basis for ‘Autistic Traits’ in Art

3.1 Insights from Research into Exceptional Talent in Realistic Depiction

‘Natural talent’ has a significant role in abilities to create realistic art, and an essential role in exceptional realism in particular. Of course, as with other fields, practice has an important effect on drawing skill (Campitelli & Gobet, 2011; Hambrick et al., 2014). However motivations to practice are influenced by talent (Winner & Drake, 2013) and most significantly where it comes to exceptional talent at realistic depiction, practice is no match for innate talent. Most of us can attain a certain level of drawing realism through modest ability, training and practice when there is time to carefully observe. However differences between trained and ‘natural talent’ are still very much apparent (Drake, 2014). Spontaneous drawing from memory of those without exceptional natural talent will lack realism whilst those who are naturally talented at realistic depiction can realistically and accurately depict what they have seen with ease.

Exceptional talent is rare and is also usually evident in childhood (Drake et al., 2010; Drake & Winner, 2013; Winner & Drake, 2013; Drake, 2014). In fact precocious artists begin to draw realistically by the age of two, whilst even a year later typically children are still drawing only in abstractions and only begin to draw three-dimensionally at around eight years old (Drake & Winner, 2017).

Recent research on the basis for exceptional talent in realistic depiction has provided important insights into what drives such talent. The *expression* of exceptional talents in realistic depiction depends on a certain level of motor skills (Pring et al., 2010) as well as cultural support and motivation (Winner & Drake, 2013) but the underlying talent is based on a unique cognition. What marks out individuals with a natural talent in realistic depiction as different is their abilities to observe hidden forms and to segment a complex form mentally (Drake, 2014). In effect they are unusually able to *observe and mentally represent three-dimensional forms*. We take our understanding of what we see for granted however we *interpret* forms in the world around us three-dimensionally from what is presented to our visual field. Assuming normal vision and cognition we can of course all *see* the world around us, and can find our way in three-dimensional space, however the extent to which anyone does this by accurately observing and understanding forms rather than constructing a generalised and coarse grain model varies. For this reason, if we are not naturally talented at realistic depiction no drugs can make us spontaneously capable of producing realistic art as the crucial element of realistic depiction lies *in years of what happens when we see* rather than the moment of drawing itself.

In psychological terms people with a natural talent at realistic depiction share the perceptual-cognitive trait of *local processing bias*. Talent at realistic drawing is determined by this trait irrespective of gender, age, IQ or level of art instruction or practice (Drake et al., 2010; Winner & Drake, 2013; Drake, 2014). The effect of how a local processing bias determines the realism of drawings made by a child naturally talented in realistic depiction can be seen in figure 2. Child A (the talented realist) has observed the ellipse of the top of the glass, and is able to mentally reconstruct the shape of the corkscrew, such that their observation of detail and internal visual model leads to a highly realistic depiction. Child B has neither observed this detail nor constructed a nuanced three-dimensioned mental model of the objects (Drake, 2014).

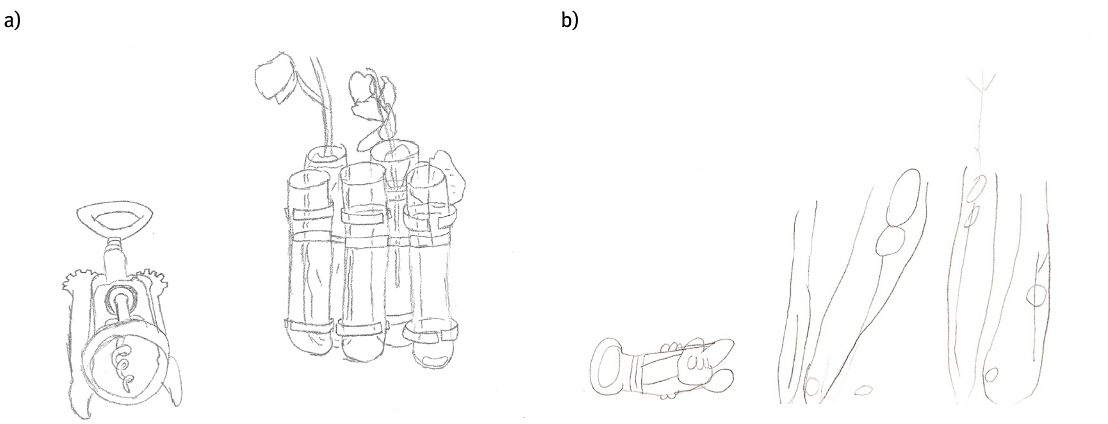


Figure 2. Vase with flowers and corkscrew drawn by a child with precocious realism (A) and a child without a gift at realistic depiction (B), both at ten years old, with photograph of the vase and corkscrew (after Drake et al., 2010, figure 4, with kind permission). Pencil drawings shown at higher contrast for clarity.

Local processing bias (also known as weak central coherence and detail focus) is measured through tests in abilities deciphering hidden forms, known as embedded figure tests (figure 3) and in reconstructing relationships between forms, known as block design test (figure 4) and is highly heritable (Happé et al., 2001; Briskman et al., 2001).

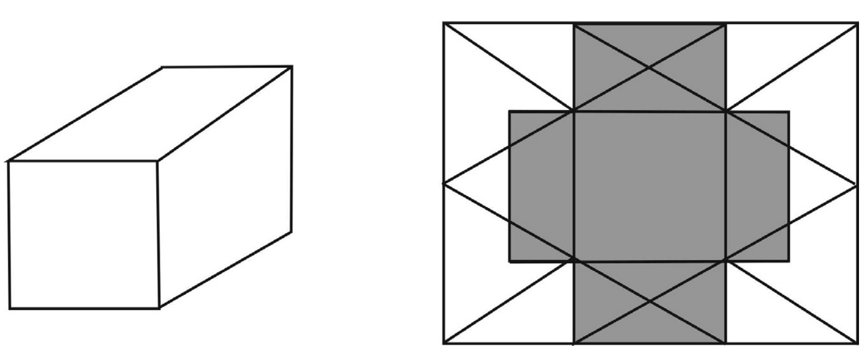


Figure 3. Example of an embedded figures test. Participants are asked to identify the figure on the left within the figure on the right.

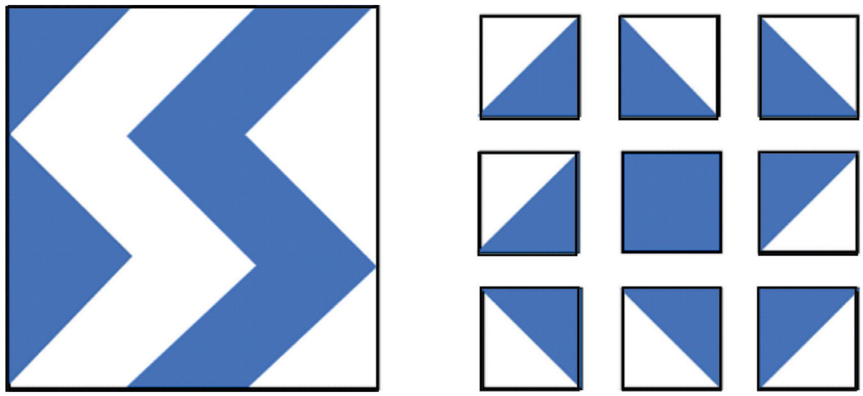


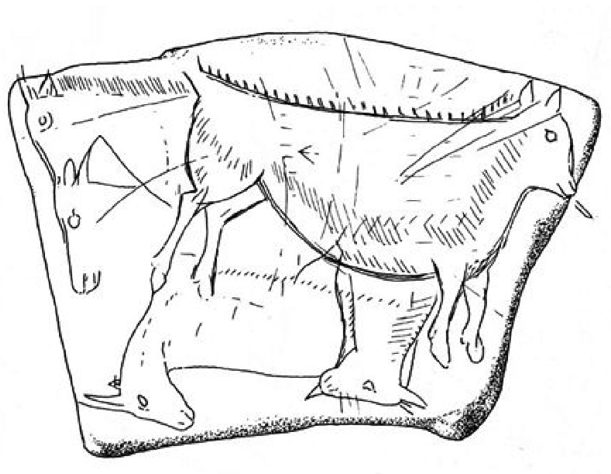
Figure 4. Example of a block design test. Participants are asked to move the blocks on the right to create the pattern on the left.

Navon (1977) and others have described the concept of global and local processing biases. When sensory stimuli (such as pictures) contain both global holistic information and details within them, we may be drawn to the overview or holistic information (global processing bias or global precedence) or we may be drawn initially to the detail within the picture (local processing bias). Whilst these are not mutually exclusive individuals may show a bias in one direction or another in the presence of differing stimuli and some of this is related to brain functioning. This is correlated with corpus callosum (CC) brain size, with the CC as the wiring relay station of the brain being a proxy for connectivity (Muller-Oehring et al., 2007).

Local processing bias, in effect 'natural talent' at observing and understanding forms is not only evident in many examples of Upper Palaeolithic art, such as the lions depicted at Chauvet Cave (figure 1) but also in other areas of Upper Palaeolithic material culture. Embedded figures are a frequent theme in mobiliary art for example, with overlapping forms often cleverly constructed within a depiction (figure 5). Whilst many of us struggle to see these embedded figures before they are pointed out to us those with local processing bias can identify them easily. A remarkable understanding of three-dimensional relationships is also seen in figurines such as the 'lion headed man' figurine from Stadel Cave in south-west Germany (Conard, 2003; Kind et al., 2014). Moreover European Upper Palaeolithic flintwork shows remarkable attention to precise form and detail (Sinclair, 2015). Researchers in exceptional artist talent in realistic depiction also note the unusual similarity between the work of those with such talent today and that of Upper Palaeolithic artists (Drake & Winner, 2017).

The effects of *our surroundings* as we develop on our abilities at realistic depiction are minor compared to the effects of innate local processing bias (or 'talent'). Modern hunter-gatherer populations and other non-industrialised or literate societies do show a measurable enhancement in some elements of observation over modern industrialised societies, for example particularly the capacity to be less influenced by optical illusions (Rozin, 2010, p. 64). However there is no unusual realism in the drawings of those modern hunter-gatherers who have been studied (Segall et al., 1966). Indeed the general tendency of hunter-gatherers taken as a group *as a whole* are not towards any more local processing style but a more global one, observing forms in terms of overall shapes rather than details (Uskul et al., 2008; Reyes-García et al., 2016), as seen in depictions of faces (Segall et al., 1966). This makes sense in that overall a quick visual and cognitive appraisal is the optimum strategy in a hunting and gathering context where immediate recognition of predators and prey are needed (Bentley & Deregowski, 1987). This doesn't mean that local processing bias and attention to details rather than 'the whole' might not have carried advantages in certain specific environments in the past.

a)



b)

c)

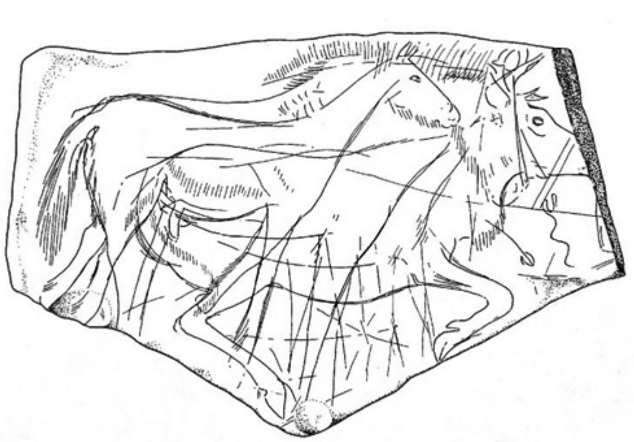


Figure 5. Example of portable art showing embedded figures (or overlapping forms). A) Plaquette 662 from Montrastruc, dated c 11,000 bp, shows five ibex cleverly depicted in different orientations on the plaquette B) & C) Plaquette 691 from the same site and date shows 3 horses, which share a tail, hindquarters and a penis and have separate heads, overlying a reindeer (images and photographs courtesy of the British Museum). Each plaquette illustrates a talent at creating and interpreting embedded figures.

3.2 The Relationship Between Local Processing Bias and Autism

Some of the most famous examples of exceptional talent at realistic depiction are those of artists who are also autistic, with Nadia being a particularly good example. This relationship only makes sense when we understand elements of the cognitive basis for autism spectrum conditions. Local processing bias is strongly associated with autism. There is good evidence that seeing the world through a local processing bias or 'not seeing the wood for the trees' is a key feature of the condition (Behrmann et al., 2006; Happé & Frith, 2006), as well as a driver for many autistic talents (Happe & Vital, 2009). Global processing is not *impossible* for most individuals with ASC, but is more difficult and demands effort (Koldewyn et al., 2013; Stevenson et al., 2016). A meta-analysis of visuo-spatial performance tests in autism spectrum disorders shows superior performance in both embedded figures testing and block design (Muth et al., 2014) and another meta-analysis suggests slower global processing in ASD (Van der Hallen et al., 2015). It is suggested that these differences are related to differences in brain connectivity (Belmonte et al., 2004) and that they profoundly affect how different individuals interact with their material and social worlds. There is wide heterogeneity, which is perhaps not surprising given both wide variability across the autism spectrum in terms of symptomatology and intelligence, and also the presence of special isolated skills in only three fifths of children with autism (Meilleur et al., 2015).

The influence of local processing bias is clear in the work of talented artists with autism. We can recognise the same pattern of observation and cognitive reconstruction of three dimensional form in the work of the talented autistic artist Stephen Wiltshire, who can draw all of New York from a twenty minute helicopter ride, as we see in preciously realistic artist without autism (Wiltshire & Casson, 1987; Wiltshire, 1989). Equally the contrast between Nadia's drawings (referred to by Humphrey (1998)) and those of a typical developing child without autism also illustrate Nadia's marked local processing bias. Thus the differences between the two share the same features as those observed between the two children with and without exceptional talent above (figure 6). Nadia's drawing is not a photographic representation of a scene, but she has observed the details of edges and forms when she saw a horse and rider, cognitively reconstructed a three-dimensional and detailed form from which she interpolates edges and thus the bounding lines which she draws. A typically developing child of the same age has however observed and mentally modelled a simpler representation of a horse and has drawn this (without for example the three-dimensional complexity needed to deal with overlapping legs). The complex mental representation of form associated with local processing bias is also even seen in the drawings of a child with Asperger Syndrome who is not a precociously talented artist but nonetheless shows the remarkable observation and three-dimensional understanding (figure 7) often seen in talented art of individuals with autism (Mottron & Belleville, 1993).

Local processing bias is an explanation for some of the talents in other spheres which are associated with ASC, such as those in engineering domains for example (Happé et al., 2001; Briskman et al., 2001). Thus the cognitive skills inherent in talents in realistic depiction are shared with other careers and interests. Drake and Winner describe two children with exceptional talent at realistic depiction whose analytical understanding of natural forms seem to lead them to careers in natural science rather than art for example (Drake & Winner, 2017). One of the authors (BW) who has run many groups with children on the autism spectrum has seen numerous children over the years with exceptional artistic talent go on to University or into careers in animation, art and a variety of other creative endeavours. Happé and Frith further argue that the advantages of an extreme cognitive focus on detail to several realms make the persistence of individuals with local processing bias within the gene pool 'not hard to explain' (Happé & Frith, 2006, p. 16).

Local processing bias is a key element of autism, but is also seen in some individuals without ASC. Given the association with autism, it is not surprising that exceptional talents at realistic depiction are not unusual in those with Asperger Syndrome however. A conservative estimate of the percentages of such individuals with exceptional talent in realistic depiction is around 6% (Mottron et al., 2006) with recent research suggesting that the actual figure may be much times higher, with one large study suggested that 62% have special isolated skills (Meilleur et al., 2015). In our large scale study of over 1000 people carried out to better understand the relationship between perception, cognition, autism and artistic talent we found that individuals with a very high autism quotient (AQ) of 32 or above, which is taken as indicative of an autism spectrum condition

a) b)

Figure 6. Drawing of a horse by Nadia (A) and by a typically developing child of the same age (B)

a) b)

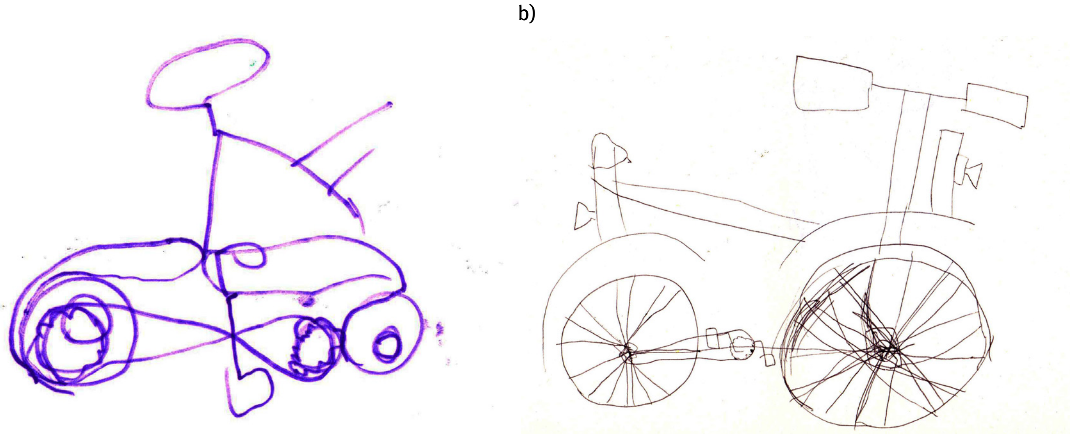


Figure 7. Drawing of a bike by a child with Asperger’s Syndrome A) at 2 years and B) at aged 4-5 years. Though this child does not have precocious drawing ability both depictions show an high level understanding of three-dimensional forms and how they relate to each other based on local processing bias.

within a population sample (Baron-Cohen et al., 2001) were statistically much more likely than neurotypical individuals (i.e. those with a lower AQ score) to have an interest in and experience of art outside of any school curriculum[1]. Some element of autism thus may influence abilities or motivations to create art. We also found that the attention to detail score overall (in the autism and overall population) was also correlated with interest in and experience of art[2]. A local processing bias both enables a talent at realistic depiction and is associated with a heightened interest in depiction and motivation to draw.

Talents at realistic depiction are not particularly unusual within the autism spectrum population and are much rarer proportionately in the neurotypical population. In a study of 153 typically developing children who were 6–12 years old none showed a comparable level of skill for example (Drake & Winner, 2013). Clearly the possibility that any individual with an exceptional talent in realistic depiction would also be given a modern diagnosis of autism would need to be researched, but is likely to be reasonably high, even taking into account the low percentage of individuals with autism compared to the general population (figure 8)[3]. Naturally it is important to be cautious and to take into account the heterogeneity of genetic causes of autism (Rosti et al., 2014), the changes in autism diagnostic criteria over time (Volkmar & McPartland, 2014), lack of stability of individual diagnosis across time (Woolfenden et al., 2012; Ozonoff et al., 2015) which will all will affect interpretation of skill prevalence when comparing different population groups.

Perhaps more significantly, outside of our modern diagnosis of 'disorder' which may not be a particularly helpful concept, individuals with exceptional talents in realistic depiction also commonly experience social traits associated with autism (Winner, 2000). What are seen as three spheres of 'deficits' in autism–social impairment, communication impairment, and restricted and repetitive behaviours and interests–have a level of separate genetic control (Happé & Ronald, 2008; Robinson et al., 2012) even though there are relationships between domains. Even outside of any diagnosis of autism a talent at realistic depiction is associated with a tendency towards sensory interests, and repetitive and compulsive behaviours (Drake et al., 2010; Robinson et al., 2016). A *compulsion to draw*, driven by a primary sensory processing difference, may not always be socially popular with one's peers but may nonetheless be an important factor in motivating exceptionally talented artists. Traits of autism can bring clearer disadvantages however and local processing bias tends to also be associated with some social deficits (Russell-Smith et al., 2012) and tendencies towards depression (de Fockert & Cooper, 2014).

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1 Our online survey of the influence of perception and cognition on art sampled 1062 people, assessing their score on the Autism Quotient (AQ), a well tested measure of autistic traits. An AQ score of 32 or above shows a high probability of a diagnosis of autism, including when individuals are assessed by a clinician (Baron-Cohen et al. 2001). We here use the AQ=32 cutoff point for what we haved termed the 'autism' sample (effectively the high AQ group), noting that this is statistically related to autism diagnosis (but not specific to individual cases). Participants came from students at York, the general population and a sample specifically from Autism Support Groups and the Autism Research Center and was distributed in the general population responding to a press release, via an open access ebook 'Autism in Prehistory' (Rounded Globe) and media engagement. Those within the range indicative of an autism spectrum condition were found to be more likely to have experience of art outside of the classroom (HR=31.79% N=302, LR=20.26% N=617, chi squared P=0.000122). Further, using analysis of variance (ANOVA) those with high experience of art were found to have a higher average AQ (f=13.5, p=<0.001).

2 Experience of art is also associated with an attention to detail score greater than 8, 33.33% of those with a high experience of art (N=221) also showed high attention to detail, whereas only 21.32% of those with a limited experience of art (N=699) showed high attention to detail (chi squared P=0.000368). This association is found both within the autism sample (51.04% high experience of art N=96, 41.75% limited experience of art N=206. Approaching statistical significance chi squared P=0.13)) and outside of the autism sample (16.00% high experience of art N=125, 10.57% limited experience of art N=492. approaching statistical significance chi squared P=0.091). Further, using ANOVA it has been found that those with high experience of art had a higher mean attention to detail score (f=7.36, p=0.007). In other words detail focus influences one's interest in and motivation to create art whether individuals would fit a diagnostic criteria for autism or not.

3 The incidence of high detail focus alone in our study (before considering other influences on exceptional talent in realistic depiction such as the influence of motivation) was approximately four times as high in the population with an AQ indicative of autism than in the neurotypical population. The percentage of individuals with an AQ of 32 or above with a high detail focus score (8 out of 10 or higher in the AQ detail component) out of the total population with an AQ of 32 or above was approximately 4% (148 individuals out of 352). The percentage of individuals with an AQ less than 32 with a high detail score (8 out of 10 in the AQ detail component) out of the total population with an AQ of less than 32 was approximately 1% (81 individuals out of 710).

Exceptional talent comes at a price, whether that price fits our modern culturally defined definition of 'autism' or not.

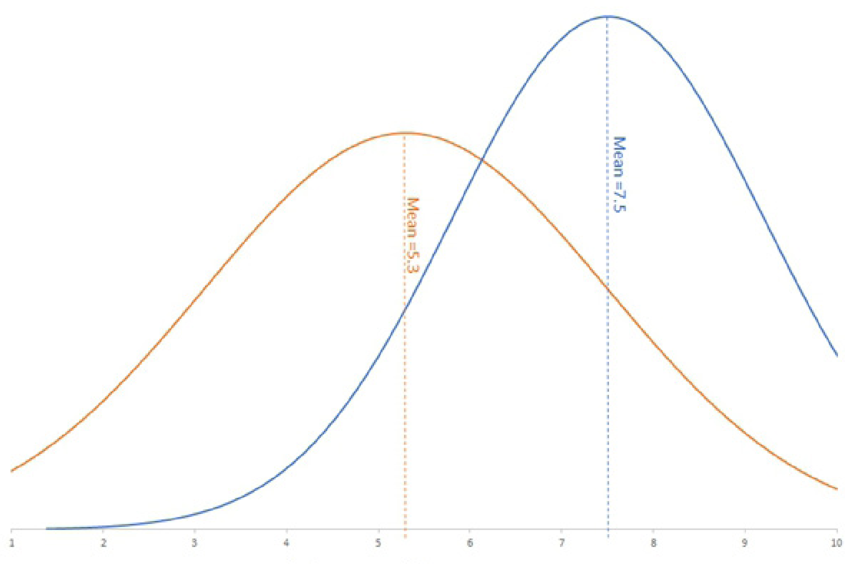

Figure 8. Distribution of detail-focus scores for general (red line, AQ is less than 32) and ASC (blue line, AQ is 32 or higher) population, based on data from a large scale population study of 1062 participants. The ASC population is substantially smaller than the neurotypical population in the general population (typically about 4% of the total). When adjusted for a natural population representation of ASC our data showed that at least 1 in 3 individuals at the highest detail score (highest level of local processing bias) would also have an ASC.

4 European Upper Palaeolithic Art and 'Autistic Traits' in Social Context

Undoubtedly social context had a significant role to play in how local processing bias became expressed in talented works in realistic depiction in the European Upper Palaeolithic.

The social and cultural context influences the extent to which any natural talents in realistic depiction would be held in high esteem. It is not uncommon for creative outputs that are not directly functional to be held in high esteem in hunter-gatherer societies. Amongst the highly egalitarian BaYaka for example those individuals who attain a level of prestige or status are those with notable musical talent, with their music seen as vital to communal rituals (Lewis, 2013). In some contexts skills in realistic depiction will have been associated with a certain influence and prestige. Zaidel for example notes that the Gola people regarded talented artists as special people, inspired by unique forces (Dissanayake, 2015 in Zaidel, 2015). In other contexts however any extreme of local processing bias (which might lead to talented realistic depiction) might bring no particular social gain in terms of status or influence. Societies may either not create 'art' or create only highly symbolic and non-realistic art. Bird-David for example demonstrates that an ideology of relatedness seen in modern immediate return hunter-gatherers mitigates against the creation of figurative or representational art as such art creates an ideologically problematic division between subject and object (Bird-David, 2006). Equally other societies place particular value on creating particularly highly symbolised, engaging, creative or challenging art, which is not focused on realism (Morphy, 2014). The European Upper Palaeolithic may however have been a social context in which skills in realistic depiction, and therefore local processing bias, were held in esteem, and any social deficits supported, resulting both in the promotion of such talents and in the support of increased creation of highly realistic and moving art images.

A certain *variation* in natural talent in the period, from which those who are more talented might be drawn, is visible archaeologically. There is some evidence for 'apprentices' implying that skills improved with practice (Rivero, 2016). Nonetheless Fritz et al. (2015) illustrates the significance of natural ability in comparison with experience. They compare two depictions on portable art objects from the cave of La Vache –the first, a depiction of an aurochs, was created by someone skilled in the technical process of engraving into bone, but with a poor drawing ability, whilst the second, a horse, was created by someone with a natural drawing talent but poor technical ability at engraving into bone (Fritz et al., 2015). They argue that 'gifted' individuals are likely to have been encouraged especially if noticed at an early age. Zaidel comments:

> *'Some individuals would have had more talent than others due to genetic variations in the population, and those with more talent would have been entrusted with depicting ideas and the real world.... Time was set aside for them and the rest of society provided support'.*(Zaidel, 2015, p. 194)

Other factors may also have coincided to place emphasis on local processing bias in the European Upper Palaeolithic specifically. The ecological context can also play a role in encouraging local processing bias for example. High latitude and cold environments (such as those in the European Upper Palaeolithic) are challenging to survival with inherent unpredictability and risk. As such they are good examples of contexts where technological skill is essential to survival, with precision, reliability and complex design of hunting weapons necessary to avoid failure (Bleed, 1986). It isn't difficult to see that the attention to detail, and engineering skill associated with local processing bias may have been placed in high esteem in such contexts (Spikins et al., 2016; Spikins & Wright, 2016). Moreover the nature of hunting techniques, with an emphasis on finding and correctly identifying prey at a distance from fragmented cues (Hodgson & Watson, 2015) may also encourage a focus on fine details.

The integration of individuals with local processing bias, whether seen as important through technological or artistic talents, has a wider social and cultural significance. Spikins (2015) and Spikins et al. (2016) argue for the wider social significance of support for individuals with disabilities and vulnerabilities for example. In the case of those for whom local processing bias also brought with it traits of autism, compulsive behaviour patterns or certain social difficulties, emerging roles for their social and technical skills (Spikins et al., 2016) would explain the positive selection for autism genes through a balance of skills and deficits. This positive selection is not surprising as our cultural connotations of 'autism' might lead us to assume. Whilst some individuals with autism spectrum conditions today are severely disabled (particularly those with autism with intellectual impairment), a more usual pattern is that of individuals whose social abilities allow them to be fully integrated and whose particular cognitive strengths allow them to fulfil significant social and technical roles.

5 Conclusions

There is little question that amongst the corpus of European Upper Palaeolithic art there are many depictions, such as the frieze of lions at Chauvet Cave for example, which are the work of exceptionally talented artists. Rather than influenced by drug use, the similarities between such art and that of talented artists with autism are shown here to be a product of a cognitive condition–local processing bias–which brings with it exceptional abilities to observe and cognitively reconstruct forms. Local processing bias is common to those with exceptional talent in realistic depiction whether associated with an autism spectrum condition or not, and is a potentially significant area for future research.

'Autistic traits' in Upper Palaeolithic art do not necessarily signify the work of an individual with autism. However, since local processing bias is common in autism and yet so rare in neurotypical populations, it is inevitable that artists–who we might today characterise as having an autism spectrum condition–played some role in the creation of some of the exceptional art of the period. Nonetheless modern culturally constructed definitions of health or disorder may not be particularly helpful in understanding the creation of Upper Palaeolithic art. What is significant is that behind the most powerful and evocative images of the

Upper Palaeolithic lay a level of tolerance and understanding which allowed talents to be encouraged and notable cognitive differences to be integrated and valued.

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Abbreviations

ASC: autism spectrum condition
SNP: single nucleotide polymorphism
CNV: copy number variation

References

Baron-Cohen, S., Bolton, P., Wheelwright, S., Scahill, V., Short, L., Mead, G., & Smith, A. (1998). Autism occurs more often in families of physicists, engineers, and mathematicians. *Autism: the international journal of research and practice* 2(3), 296–301. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.178.132&rep=rep1&type=pdf.

Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001). The Autism-Spectrum Quotient (AQ): Evidence from Asperger Syndrome/High-Functioning Autism, Males and Females, Scientists and Mathematicians. *Journal of autism and developmental disorders* 31(1), 5–17. doi:10.1023/A:1005653411471. http://link.springer.com/article/10.1023/A:1005653411471 (8 August, 2016).

Bednarik, R. G.(2013). Brain Disorder and Rock Art. *Cambridge Archaeological Journal* 23(01), 69–81. doi:10.1017/S095977431300005X. http://journals.cambridge.org/abstract_S095977431300005X (17 January, 2016).

Bednarik, R. G. (2016). *Myths about Rock Art*. Oxford, UK: Archaeopress. https://market.android.com/details?id=book-QaZ9vgAACAAJ.

Behrmann, M., Thomas, C., & Humphreys, K. (2006). Seeing it differently: visual processing in autism. *Trends in cognitive sciences* 10(6), 258–264. doi:10.1016/j.tics.2006.05.001. http://dx.doi.org/10.1016/j.tics.2006.05.001.

Belmonte, M. K., Allen, G., Beckel-Mitchener, A., Boulanger, L. M., Carper, R. A., & Webb, S. J. (2004). Autism and abnormal development of brain connectivity. *Journal of Neuroscience*, 24(42), 9228-9231.

Bentley, A. M. & Deregowski, J. B. (1987). Pictorial experience as a factor in the recognition of incomplete pictures. *Applied cognitive psychology* 1(3), 209–216. doi:10.1002/acp.2350010306. http://dx.doi.org/10.1002/acp.2350010306.

Bird-David, N. (2006). Animistic epistemology: Why do some hunter-gatherers not depict animals? *Ethnos* 71(1), 33–50. doi:10.1080/00141840600603152. http://dx.doi.org/10.1080/00141840600603152.

Bleed, P. (1986). The Optimal Design of Hunting Weapons: Maintainability or Reliability. *American Antiquity* 51(4), 737–747. doi:10.2307/280862. http://www.jstor.org/stable/280862.

Bonvin, C., Horvath, J., Christe, B., Landis, T., & Burkhard, P. R. (2007). Compulsive singing: another aspect of punding in Parkinson’s disease. *Annals of neurology* 62(5), 525–528. doi:10.1002/ana.21202. http://dx.doi.org/10.1002/ana.21202.

Briskman, J., Frith, U., & Happé, F. (2001). Exploring the Cognitive Phenotype of Autism: Weak “Central Coherence” in Parents and Siblings of Children with Autism: II. Real-life Skills and Preferences. *Journal of child psychology and psychiatry, and allied disciplines* 42(3), 309–316. doi:10.1017/S0021963001006904. https://www.cambridge.org/core/journals/journal-of-child-psychology-and-psychiatry-and-allied-disciplines/article/exploring-the-cognitive-phenotype-of-autism-weak-central-coherence-in-parents-and-siblings-of-children-with-autism-ii-real-life-skills-and-preferences/EE3740E3E8EDB3693383C4E0DBC0E2EF (13 April, 2017).

Campitelli, G. & Gobet, F. (2011). Deliberate Practice. *Current directions in psychological science* 20(5), 280–285. doi:10.1177/0963721411421922. http://dx.doi.org/10.1177/0963721411421922.

Canesi, M., Rusconi, M. L., Isaias, I. U., & Pezzoli. G.(2012). Artistic productivity and creative thinking in Parkinson’s disease. *European journal of neurology: the official journal of the European Federation of Neurological Societies* 19(3), 468–472. doi:10.1111/j.1468-1331.2011.03546.x. http://dx.doi.org/10.1111/j.1468-1331.2011.03546.x.

Conard, N. J. (2003). Palaeolithic ivory sculptures from southwestern Germany and the origins of figurative art. *Nature* 426(6968). nature.com. 830–832. doi:10.1038/nature02186. http://dx.doi.org/10.1038/nature02186.

De Rios, M. D. & Janiger, O. (2003). *LSD, spirituality, and the creative process: Based on the groundbreaking research of Oscar Janiger, MD*. Maine USA: Park Street Press.

Dissanayake, E. (2015). *What Is Art For?* University of Washington Press: Washington, USA

Drake, J. E. (2014). Knowing how to look predicts the ability to draw realistically. *The British journal of developmental psychology* 32(4), 397–414. doi:10.1111/bjdp.12048. http://dx.doi.org/10.1111/bjdp.12048.

Drake, J. E., edash, A., Coleman, K., Haimson, J., & Winner, E. (2010). "Autistic" Local Processing Bias also Found in Children Gifted in Realistic Drawing. *Journal of autism and developmental disorders* 40(6), 762–773. doi:10.1007/s10803-009-0923-0. https://link.springer.com/article/10.1007/s10803-009-0923-0 (18 March, 2017).

Drake, J. E. & Winner, E. (2013). Children gifted in drawing. *Gifted Education International* 29(2), 125–139. doi:10.1177/0261429412447708. http://dx.doi.org/10.1177/0261429412447708.

Drake, J. E. & Winner, E. (2017). Predicting Artistic Brilliance. *Scientific American* 26, 2–18. doi:10.1038/scientificamerican-creativity0317-12. http://dx.doi.org/10.1038/scientificamericancreativity0317-12 (8 April, 2017).

Faughn, C., Marrus, N., Shuman, J., Ross, S. R., Constantino, J. N., Pruett Jr, J.R., & Povinelli, D. J. (2015). Brief Report: Chimpanzee Social Responsiveness Scale (CSRS) Detects Individual Variation in Social Responsiveness for Captive Chimpanzees. *Journal of autism and developmental disorders* 45(5), 1483–1488. doi:10.1007/s10803-014-2273-9. http://dx.doi.org/10.1007/s10803-014-2273-9.

Fockert, J. W. de & Cooper, A. (2014). Higher levels of depression are associated with reduced global bias in visual processing. *Cognition & emotion* 28(3), 541–549. doi:10.1080/02699931.2013.839939. http://dx.doi.org/10.1080/02699931.2013.839939.

Fritz, C., & Tosello, G. (2000). Observations Techniques Sur Le Panneau Des Chevaux de La Grotte Chauvet (Ardèche): L'exemple Des Rhinocéros Affrontés. *INORA: International Newsletter on Rock Art 26. Ministère de la Culture*: 23–30.

Fritz, C., & Tosello, G. (2007). The hidden meaning of forms: methods of recording Paleolithic parietal art. *Journal of Archaeological Method and Theory* 14(1), 48-80.

Fritz, C., Tosello, G., & Conkey, M. W. (2015). Reflections on the Identities and Roles of the Artists in European Paleolithic Societies. *Journal of Archaeological Method and Theory* 23(4), 1307–1332. doi:10.1007/s10816-015-9265-8. http://link.springer.com/article/10.1007/s10816-015-9265-8 (3 January, 2017).

Gaugler, T., Klei, L., Sanders, S. J., Bodea, C. A., Goldberg, A. P., Lee, A. B., Mahajan, … Buxbaum, J. D (2014). Most genetic risk for autism resides with common variation. *Nature genetics* 46(8), 881–885. doi:10.1038/ng.3039. http://dx.doi.org/10.1038/ng.3039.

Gualtieri, C. T. (2014). Autism and Schizophrenia Are Disorders of Evolvability. *Open journal of medical psychology* (2014). http://file.scirp.org/Html/7-2250080_42577.htm.

Guerra-Doce, E. (2015). Psychoactive Substances in Prehistoric Times: Examining the Archaeological Evidence. *Time and Mind* 8(1), 91–112. doi:10.1080/1751696X.2014.993244. http://www.tandfonline.com/doi/abs/10.1080/1751696X.2014.993244.

Hambrick, D. Z., Oswald, F. L., Altmann, E. M., Meinz, E. J., Gobet, F., & Campitelli, G. (2014). Deliberate practice: Is that all it takes to become an expert? *Intelligence* 45, 34–45. http://www.sciencedirect.com/science/article/pii/S0160289613000421.

Happé, F., Frith, U., & Briskman, J. (2001). Exploring the Cognitive Phenotype of Autism: Weak "Central Coherence" in Parents and Siblings of Children with Autism: I. Experimental Tests. *Journal of child psychology and psychiatry, and allied disciplines* 42(3), 299–307. doi:10.1017/S0021963001006916. https://www.cambridge.org/core/journals/journal-of-child-psychology-and-psychiatry-and-allied-disciplines/article/exploring-the-cognitive-phenotype-of-autism-weak-central-coherence-in-parents-and-siblings-of-children-with-autism-i-experimental-tests/E34CF2ADC47C9A5DE9781609C50DAAB0 (13 April, 2017).

Happé, F.& Frith, U. (20060. The weak coherence account: detail-focused cognitive style in autism spectrum disorders. *Journal of autism and developmental disorders* 36(1), 5–25. doi:10.1007/s10803-005-0039-0. http://dx.doi.org/10.1007/s10803-005-0039-0.

Happé, F.& Ronald, A. (2008). The "fractionable autism triad": a review of evidence from behavioural, genetic, cognitive and neural research. *Neuropsychology review* 18(4), 287–304. doi:10.1007/s11065-008-9076-8. http://dx.doi.org/10.1007/s11065-008-9076-8.

Happe, F. & Vital, P. (2009). What aspects of autism predispose to talent? *Philosophical transactions of the Royal Society of London. Series B, Biological sciences* 364(1522), 1369–1375. doi:10.1098/rstb.2008.0332. http://rstb.royalsocietypublishing.org/cgi/doi/10.1098/rstb.2008.0332.

Haworth, K. (2006). Upper Paleolithic art, autism, and cognitive style: Implications for the evolution of language. *Semiotica* 162, 127-174.

Hodgson, D. & Watson, B. (2015). The visual brain and the early depiction of animals in Europe and Southeast Asia. World archaeology 47(5), 776–791. doi:10.1080/00438243.2015.1074871

Huguet, G., Benabou, M., & Bourgeron, T. (2016). The Genetics of Autism Spectrum Disorders. In Paolo Sassone-Corsi & Yves Christen (Eds.), *A Time for Metabolism and Hormones* (pp. 101–129). (Research and Perspectives in Endocrine Interactions). Springer International Publishing.

Humphrey, N. (1998). Cave Art, Autism, and the Evolution of the Human Mind. *Cambridge Archaeological Journal* 8(02), 165–191. doi:10.1017/S0959774300001827. http://journals.cambridge.org/abstract_S0959774300001827 (17 January, 2016).

Humphrey, N. (2002). Commentary on Michael Winkelman, "Shamanism and Cognitive Evolution." *Cambridge Archaeological Journal* 12(1), 91–93. doi:10.1017/S0959774302000045. http://philpapers.org/rec/HUMCOM.

Muth, A., Hönekopp, J., & Falter, C. M. (2014). Visuo-spatial performance in autism: a meta-analysis. *Journal of Autism and Developmental Disorders*, 44(12), 3245–3263.

Iossifov, I., O'Roak, B. J., Sanders, S. J., Ronemus, M., Krumm, N., Levy, D., Stessman, H. A., … Wigler, M. (2014). The contribution of de novo coding mutations to autism spectrum disorder. *Nature* 515(7526), 216–221. doi:10.1038/nature13908. http://dx.doi.org/10.1038/nature13908.

Janiger, O. & De Rios, M. D. (1989). LSD and creativity. *Journal of psychoactive drugs* 21(1), 129–134.

Kellman, J. (1998). Ice Age Art, Autism, and Vision: How We See/How We Draw. *Studies in Art Education* 39(2), 117–131. doi:10.2307/1320464. http://www.jstor.org/stable/1320464.

Kind, C.-J., Ebinger-Rist, N., Wolf, S., Beutelspacher, T., & Wehrberger, K. (2014). The smile of the Lion Man. Recent excavations in Stadel Cave (Baden-Württemberg, southwestern Germany) and the restoration of the famous Upper Palaeolithic figurine. *Quartär* 61. academia.edu. 129–145. http://www.academia.edu/download/41188807/Kind_etal_LionMan_QU_61.pdf.

Klei, L., Sanders, S. J., Murtha, M. T., Hus, V., Lowe, J. K., Willsey, A. J, Moreno-De-Luca, D, … , Devlin, B. (2012). Common genetic variants, acting additively, are a major source of risk for autism. *Molecular autism* 3(9). doi:10.1186/2040-2392-3-9. http://dx.doi.org/10.1186/2040-2392-3-9.

Koldewyn, K., Jiang, Y. V., Weigelt, S., & Kanwisher, N. (2013). Global/local processing in autism: not a disability, but a disinclination. *Journal of autism and developmental disorders* 43(10), 2329–2340. doi:10.1007/s10803-013-1777-z. http://dx.doi.org/10.1007/s10803-013-1777-z.

Lewis, J. (2013). A cross-cultural perspective on the significance of music and dance to culture and society insight from BaYaka pygmies. In Michael A. Arbib (Ed.), *Language, Music, and the Brain* (pp. 45–65). Cambridge, Massachusetts, USA: MIT Press.

Liu, L., Lei, J., Sanders, S. J., Willsey, A. J., Kou, Y, Cicek, A. E, Klei, L., … , Roeder, K. (2014). DAWN: a framework to identify autism genes and subnetworks using gene expression and genetics. *Molecular autism* 5(1). 22. doi:10.1186/2040-2392-5-22. http://dx.doi.org/10.1186/2040-2392-5-22.

Lorenz, T. & Heinitz, K. (2014). Aspergers–Different, Not Less: Occupational Strengths and Job Interests of Individuals with Asperger's Syndrome. *PloS one*, *9*(6), p.e100358.

Marques-Bonet, T. & Eichler, E. E. (2009). The evolution of human segmental duplications and the core duplicon hypothesis. *Cold Spring Harbor symposia on quantitative biology* 74, 355–362. doi:10.1101/sqb.2009.74.011. http://dx.doi.org/10.1101/sqb.2009.74.011.

Marrus, N., Faughn, C., Shuman, J., Petersen, s. E., Constantino, J. N., Povinelli, D. J., & Pruett Jr., J. R. (2011). Initial Description of a Quantitative, Cross-Species (Chimpanzee–Human) Social Responsiveness Measure. *Journal of the American Academy of Child and Adolescent Psychiatry* 50(5), 508–518. doi:10.1016/j.jaac.2011.01.009. http://www.sciencedirect.com/science/article/pii/S0890856711000566.

Meilleur, A.-A. S., Jelenic, P., & Mottron, L. (2015). Prevalence of clinically and empirically defined talents and strengths in autism. *Journal of autism and developmental disorders* 45(5), 1354–1367. doi:10.1007/s10803-014-2296-2. http://dx.doi.org/10.1007/s10803-014-2296-2.

Morphy, H. (2014). *Animals Into Art*. Abingdon, Uk: Routledge.

Mottron, L. & Belleville, S. (1993). A study of perceptual analysis in a high-level autistic subject with exceptional graphic abilities. *Brain and cognition*, 23(2), 279–309.

Mottron, L., Dawson, M., Soulières, I., Hubert, B., & Burack, J. (2006). Enhanced perceptual functioning in autism: an update, and eight principles of autistic perception. *Journal of autism and developmental disorders* 36(1), 27–43. doi:10.1007/s10803-005-0040-7. http://dx.doi.org/10.1007/s10803-005-0040-7.

Müller-Oehring, E. M., Schulte, T., Raassi, C., Pfefferbaum, A., &Sullivan, E.V. (2007). Local–global interference is modulated by age, sex and anterior corpus callosum size. *Brain Research*, 1142, 189–205.

Muth, A., Hönekopp, J., & Falter, C. M. (2014). Visuo-Spatial Performance in Autism: A Meta-Analysis. *Journal of Autism and Developmental Disorders* 44(12), 3245–63.

Navon, D. (1977). Forest before trees: The precedence of global features in visual perception. *Cognitive psychology* 9(3), 353–383.

Oksenberg, N., Stevison, L., Wall, J.D., & Ahituv, N. (2013). Function and regulation of AUTS2, a gene implicated in autism and human evolution. *PLoS genetics* 9(1). e1003221. doi:10.1371/journal.pgen.1003221. http://dx.doi.org/10.1371/journal.pgen.1003221.

Ozonoff, S., Young, G. S., Landa, R. J., Brian, J., Bryson, S., Charman, T., Chawarska, K., Macari, S. L., Messinger, D., Stone, W. L., & Zwaigenbaum, L. (2015). Diagnostic stability in young children at risk for autism spectrum disorder: a baby siblings research consortium study. *Journal of Child Psychology and Psychiatry*, 56(9), 988–998.

Pickard, Catriona, Ben Pickard & Clive Bonsall. 2011. Autistic Spectrum Disorder in Prehistory. *Cambridge Archaeological Journal* 21(03), 357–364. doi:10.1017/S0959774311000412. http://journals.cambridge.org/abstract_S0959774311000412 (28 June, 2016).

Polimanti, R. & Gelernter, J. (2017). Widespread signatures of positive selection in common risk alleles associated to autism spectrum disorder. *PLoS genetics* 13(2). e1006618. doi:10.1371/journal.pgen.1006618. http://dx.doi.org/10.1371/journal.pgen.1006618.

Pring, L., Ryder, N., Crane, L., & Hermelin, B. (2010). Local and global processing in savant artists with autism. *Perception* 39(8). pec.sagepub.com. 1094–1103. doi:10.1068/p6674. http://dx.doi.org/10.1068/p6674.

Reyes-García, V., Pyhälä, A., Díaz-Reviriego, I., Duda, R., Fernández-Llamazares, A., Gallois, S., Guèze, M., & Napitupulu, L. (2016). Schooling, Local Knowledge and Working Memory: A Study among Three Contemporary Hunter-Gatherer Societies. *PloS one* 11(1). e0145265. doi:10.1371/journal.pone.0145265. http://dx.doi.org/10.1371/journal.pone.0145265.

Rivero, O. (2016). Master and Apprentice: Evidence for Learning in Palaeolithic Portable Art. *Journal of Archaeological Science* 75, 89–100.

Robinson, E. B., Pourcain, B. St., Anttila, V., & Kosmicki, J. A. (2016). Genetic risk for autism spectrum disorders and neuropsychiatric variation in the general population. *Genetics*. nature.com. http://www.nature.com/ng/journal/v48/n5/abs/ng.3529.html.

Robinson, E. B., Koenen, K. C., McCormick, M. C., Munir, K., Hallett, V., Happé, F., Plomin, R., & Ronald, A. (2012). A multivariate twin study of autistic traits in 12-year-olds: testing the fractionable autism triad hypothesis. *Behavior genetics* 42(2), 245–255. doi:10.1007/s10519-011-9500-3. http://dx.doi.org/10.1007/s10519-011-9500-3.

Ronemus, M., Iossifov, I., Levy, D., & Wigler, M. (2014). The role of de novo mutations in the genetics of autism spectrum disorders. *Nature reviews. Genetics* 15(2), 133–141. doi:10.1038/nrg3585. http://dx.doi.org/10.1038/nrg3585.

Rosti, R. O., Sadek, A. A., Vaux, K. K., & Gleeson, J.G. (2014). The genetic landscape of autism spectrum disorders. *Developmental Medicine & Child Neurology*, 56(1), 12–18.

Rozin, P. (2010). The weirdest people in the world are a harbinger of the future of the world. *The Behavioral and brain sciences* 33(2-3), 108–109. http://journals.cambridge.org/article_S0140525X10000312.

Russell-Smith, S. N., Maybery, M. T., Bayliss, D. M., & Adelln, A. H. Sng. (2012). Support for a link between the local processing bias and social deficits in autism: an investigation of embedded figures test performance in non-clinical individuals. *Journal of autism and developmental disorders* 42(11), 2420–2430. doi:10.1007/s10803-012-1506-z. http://dx.doi.org/10.1007/s10803-012-1506-z.

Schartner, M. M., Carhart-Harris, R. L., Barrett, A. B., Seth, a. K., & Muthukumaraswamy, S. D. (2017). Increased spontaneous MEG signal diversity for psychoactive doses of ketamine, LSD and psilocybin. *Scientific reports* 7. 46421. doi:10.1038/srep46421. http://dx.doi.org/10.1038/srep46421.

Segall, M. H., Campbell, D. T., & Herskovits, M. J. (1966). *The influence of culture on visual perception*. Indianapolis, USA: Bobbs-Merrill. http://www.web.mit.edu/allanmc/www/socialperception14.pdf.

Sessa, B. (2008). Is it time to revisit the role of psychedelic drugs in enhancing human creativity? *Journal of psychopharmacology* 22(8), 821–827. doi:10.1177/0269881108091597. http://dx.doi.org/10.1177/0269881108091597.

Sinclair, A. (2015). All in a day's work? Early conflicts in expertise, life history and time management. In F. Coward, R. Hosfield, M. Pope & F. Wenban-Smith (Ed.), *Settlement, Society and Cognition in Human Evolution*, 94–116. Cambridge, UK: Cambridge University Press.

Spikins, P. (2009). Autism, the integrations of "difference"and the origins of modern human behaviour. *Cambridge Archaeological Journal* 19(02), 179–201. http://journals.cambridge.org/abstract_S0959774309000262.

Spikins, P. (2015). *How Compassion Made Us Human: The Evolutionary Origins of Tenderness, Trust and Morality*. Barnsley, UK: Pen and Sword.

Spikins, P. & Wright, B. (2016). *The Prehistory of Autism*. Rounded Globe. https://roundedglobe.com/books/9673edbf-0ba5-47b1-97bd-16ef244fd148/The%20Prehistory%20of%20Autism/.

Spikins, P., Wright, B., & Hodgson, D. (2016). Are there alternative adaptive strategies to human pro-sociality? The role of collaborative morality in the emergence of personality variation and autistic traits. *Time and Mind* 9(4), 289–313. doi:10.1080/1751696X.2016.1244949. http://dx.doi.org/10.1080/1751696X.2016.1244949.

Stevenson, R. A., Sun, S. Z., Hazlett, N., Cant, J. S., Barense, M, D., & Ferber, S. (2016). Seeing the Forest and the Trees: Default Local Processing in Individuals with High Autistic Traits Does Not Come at the Expense of Global Attention. *Journal of autism and developmental disorders*. doi:10.1007/s10803-016-2711-y. http://dx.doi.org/10.1007/s10803-016-2711-y.

Thorpe, N. (2016). The Palaeolithic Compassion Debate–Alternative Projections of Modern-Day Disability into the Distant Past. *Care in the Past: Archaeological and Interdisciplinary Perspectives*. Oxbow Books: Oxford: 93.

Tréhin, P. (2003). Palaeolithic art and autistic savant syndrome. *Autism Europe Conference, Lisbon 2003.* Unpublished presentation.

Uskul, A. K., Kitayama, S., & Nisbett, R. E. (2008). Ecocultural basis of cognition: farmers and fishermen are more holistic than herders. *Proceedings of the National Academy of Sciences of the United States of America* 105(25), 8552–8556. doi:10.1073/pnas.0803874105. http://dx.doi.org/10.1073/pnas.0803874105.

Van der Hallen, R., Evers, K., Brewaeys, K., Van den Noortgate, W., & Wagemans, J. (2015). Global processing takes time: A meta-analysis on local–global visual processing in ASD. *Psychological Bulletin* 141(3), 549–573

Volkmar, F. R. & McPartland, J. C. (2014). From Kanner to DSM-5: autism as an evolving diagnostic concept. *Annual review of clinical psychology*, 10, 193–212.

Wakabayashi, A., Baron-Cohen, S., Uchiyama, T., Yoshida, Y., Kuroda, M., & Wheelwright, S. (2007). Empathizing and systemizing in adults with and without autism spectrum conditions: cross-cultural stability. *Journal of autism and developmental disorders* 37(10), 1823–1832. doi:10.1007/s10803-006-0316-6. http://dx.doi.org/10.1007/s10803-006-0316-6.

Warrier, V., Bethlehem, R. A. I., Geschwind, D., & Baron-Cohen, S. (2016). Genetic overlap between educational attainment, schizophrenia and autism. *bioRxiv*. doi:10.1101/093575. http://biorxiv.org/content/early/2016/12/12/093575 (18 December, 2016).

Wiltshire, S. (1989). *Cities*. London, UK: Dent.

Wiltshire, S. & Sir Casson, H. M. (1987). *Drawings*. London, UK: Dent.

Winner, E. (2000). The origins and ends of giftedness. *The American psychologist* 55(1), 159–169. https://www.ncbi.nlm.nih.gov/pubmed/11392860.

Winner, E. & Drake, J. E. (2013). The rage to master: The decisive role of talent in the visual arts. In Scott B Kaufman (Ed.), *The complexity of greatness: Beyond talent or practice* (pp. 333–366). Oxford University Press: Oxford.

Woolfenden, S., Sarkozy, V., Ridley, G., & Williams, K. (2012). A systematic review of the diagnostic stability of autism spectrum disorder. *Research in Autism Spectrum Disorders* 6(1), 345–354.

Yoshida, K., Go,Y., Kushima, I., Toyoda, A., Fujiyama, A., Imai, H., Saito,N., Iriki, A., Ozaki, N., & Isoda, M. (2016). Single-neuron and genetic correlates of autistic behavior in macaque. *Science Advances* 2(9). e1600558. doi:10.1126/sciadv.1600558. http://advances.sciencemag.org/content/2/9/e1600558 (26 September, 2016).

Zaidel, D. W. (2014). Creativity, brain, and art: biological and neurological considerations. *Frontiers in human neuroscience* 8. 389. doi:10.3389/fnhum.2014.00389. http://dx.doi.org/10.3389/fnhum.2014.00389.

Zaidel, D. W. (2015). *Neuropsychology of Art: Neurological, Cognitive, and Evolutionary Perspectives*. Psychology Press. Hove, UK.