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TITLE: How do we explain 'autistic traits' in European Upper Palaeolithic art?

RUNNING TITLE: 'Autistic traits' in European Upper Palaeolithic art

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

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*.

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

64 autism on Upper Palaeolithic art (Spikins 2009), with talented individuals with autism potentially
65 influencing other artists (Spikins, Wright 2016).
66
67 The debate over such traits became heated. Humphrey amended his perspective to suggest that
68 psychotropic drugs may play a role in the similarities (Humphrey 2002) and forceful counter-
69 arguments to the idea of any involvement of individuals with autism in Upper Palaeolithic art were
70 put forward by Pickard et al. (2011) and Bednarik (2013, 2016). Pickard and colleagues argued that
71 autism is a disorder, associated with social deficits which would prevent individuals from making
72 such a contribution without modern medical and educational support. When such individuals
73 sporadically appeared they would not benefit from the kinds of support needed to allow them to be
74 influential or make a contribution. Bednarik (2013) added that any incorporation of vulnerable
75 members of society occurred too late to have influenced Palaeolithic art, stating the individuals with
76 autism would not have been socially tolerated or genetically included in palaeolithic societies, and
77 their involvement was therefore a 'fairy tale' (Bednarik 2016). Pickard et al. (2011) ascribed the
78 autistic traits seen in Upper Palaeolithic art to the influence of psychotropic drugs, whilst Bednarik
79 (2013) ascribed the same traits to sensory deprivation and trance.
80
81 There are of course certain *differences* between European Upper Palaeolithic art and that of
82 talented individuals with autism. Most notably there are differences in perspective, with talented
83 autistic artists usually displaying foreshortening and Upper Palaeolithic animals typically shown with
84 twisted perspective (ie a side view with elements such as ears and horns show partly from the front).
85 Comparisons have also yet to be made to reveal similarities or differences in the sequences of
86 production (as demonstrated by Fritz and Tomasello 2000; 2007 for Upper Palaeolithic art at
87 Chauvet cave for example).Nonetheless explanations for the notable *similarities* between the
88 famous depictions in Upper Palaeolithic art and those of exceptionally talented artists with autism -

89 that such art shows an understanding of perspective and foreshortening, a superimposition of forms,
90 a focus on parts of forms and above all an *exceptional realism* (see example of lions from Chauvet
91 Cave *figure 1*) - remain to be fully understood. Explanations remain hotly contested. Kellman (1998)
92 and Humphrey (1998) focus their attention on similar perceptual or cognitive systems as potential
93 explanations, Spikins (2009) focuses on a cultural influence of autism spectrum conditions, and
94 Pickard et al. (2011) , Bednarik (2013) and latterly Humphrey (2002) focus on altered states of
95 consciousness through sensory deprivation or psychotropic drugs influencing artistic skills.
96
97 [INSERT FIGURE 1 HERE]
98
99 ## A new interpretation
100
101 Here we argue that drug use cannot explain autistic traits in European Upper Palaeolithic art, and
102 moreover individuals with autism spectrum conditions (ASC) were present and playing a role in
103 Upper Palaeolithic societies. However, rather than individuals with ASC *per se*, we argue that
104 individuals with a cognitive bias towards perceiving fine detail, those with extreme *local processing*
105 *bias*, are key to the exceptionally talented realistic depiction and other 'autistic traits' seen in some
106 of the most well known Upper Palaeolithic art. Local processing bias is common in autism but also
107 seen in individuals without autism, with its influence also seen in other material culture of the
108 period.
109
110 **Psychotropic drugs, autistic traits and exceptional realism in art**
111 It is certainly tempting to believe that we all have a latent talent at art which could be revealed
112 through drug use. Psychotropic drugs, altered states of consciousness and even brain damage
113 certainly change our sensory experience and how we think and act. Moreover it is entirely

114 reasonable to suggest that societies in the Palaeolithic *may* have used psychotropic drugs. Drug use
115 is commonly reported ethnographically in hunter-gatherer contexts and moreover Guerra-Doce uses
116 archaeological evidence to argue for widespread evidence of drug use in prehistoric societies post
117 8,000bp (2015). Even without drugs societies in the Palaeolithic may have attained altered states of
118 consciousness through trance or sensory deprivation in ways that might affect their depictions.
119
120 Crucially however whilst drugs and changes to the brain can affect *artistic production* and *influence*
121 *novel ideas* they do not increase *capacities for realistic depiction*.
122
123 Psychedelic drugs, such as LSD and mescalin for example, have attracted attention as being
124 associated with changes in *creativity*. Psychedelic drugs do change sensory experience, and create
125 changes in emotions and an expansion of an individual's sense of thought and identity (Sessa 2008,
126 Schartner et al. 2017). Some of the largest studies were carried out in the late 1950s and 1960s for
127 example. The largest study was one in which LSD sessions were facilitated for almost 1000 people
128 between ages 18 and 81 in a long term series of experiments between 1954 and 1962, in which
129 artistic output was recorded (De Rios, Janiger 2003). Artistic output was affected by the drug taking,
130 becoming more expressionistic, and showing a sharpening of colour and greater freedom from
131 accepted norms. Significantly however no improvement in realism or accuracy in depiction has ever
132 been recorded in this or other studies (e.g. see Janiger & De Rios, 1989). Psychedelic drugs can
133 change the nature of artistic output but in ways that move away from, rather than towards,
134 exceptional realism.
135
136 Other promising contenders for drugs which might affect artistic production are dopaminergic drugs,
137 such as those used to treat Parkinson's disease. There *have* been anecdotal accounts of individuals
138 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 2014:5)

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).

188 The fact of positive selection of autism without intellectual disability (which is not necessarily
189 disabling) suggests that these genes bring advantages, leading to survival and procreation. Whilst
190 there are those who suggest this positive selection would not have been present in the paleolithic,
191 there are a number of arguments to suggest that it would. Firstly, the genetic evidence confirms that
192 individuals with autism *were* present in the Palaeolithic. Secondly evidence is growing that some
193 advantageous elements related to genes associated with autism have been subject to positive
194 selection (Warrier et al. 2016, Polimanti, Gelernter 2017). Thirdly the phenotypes of those who have
195 autism spectrum conditions without intellectual disability carry a number of strengths including
196 significant perceptual abilities and special skills (Meilleur et al, 2015) improved concentration, ability
197 to recognise patterns, and strong factual memory (Lorenz & Heinitz, 2014) all likely to be of benefit
198 in Upper Paleolithic environments (Spikins, Wright and Hodgson, 2015). Lastly, the final piece of the
199 jigsaw is that the community they live in needs to value them and it is precisely this time in history
200 where Thorpe (2016) argues that the presence of empathic behaviour and caring should be treated
201 in the light of current evidence as the null hypothesis. Archaeological interpretations can no longer
202 discount the influence of individuals with ASC in past societies. Indeed Spikins et al. (2016) have
203 argued for example that the incorporation of autism is explained through understanding that autism
204 spectrum conditions are not asocial, but *differently social*, with individuals with autism without
205 intellectual impairment potentially bringing important skills and fulfilling important roles in society in
206 the past, as in the present.
207
208 Does this mean that talented individuals with ASC created some of the most exceptional depictions
209 in European Upper Palaeolithic art? Not necessarily. Exceptional precocious talent in realistic
210 depiction, associated with other traits such as focus on detail or overlapping forms, is also, rarely,
211 seen outside of autism. 'Autistic traits' are thus something of a misnomer, with their explanation
212 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.

The cognitive basis for 'autistic traits' in art

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).

[INSERT FIGURE 2 HERE]

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).

[INSERT FIGURE 3 HERE]

[INSERT FIGURE 4 HERE]

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

288 within a depiction (figure 5). Whilst many of us struggle to see these embedded figures before they
289 are pointed out to us those with local processing bias can identify them easily. A remarkable
290 understanding of three-dimensional relationships is also seen in figurines such as the 'lion headed
291 man' figurine from Stadel Cave in south-west Germany (Conard 2003, Kind et al. 2014). Moreover
292 European Upper Palaeolithic flintwork shows remarkable attention to precise form and detail
293 (Sinclair 2015). Researchers in exceptional artist talent in realistic depiction also note the unusual
294 similarity between the work of those with such talent today and that of Upper Palaeolithic artists
295 (Drake, Winner 2017).
296
297 [INSERT FIGURE 5 HERE]
298
299 The effects of *our surroundings* as we develop on our abilities at realistic depiction are minor
300 compared to the effects of innate local processing bias (or 'talent'). Modern hunter-gatherer
301 populations and other non-industrialised or literate societies do show a measurable enhancement in
302 some elements of observation over modern industrialised societies, for example particularly the
303 capacity to be less influenced by optical illusions (Rozin 2010:64). However there is no unusual
304 realism in the drawings of those modern hunter-gatherers who have been studied (Segall et al.
305 1966). Indeed the general tendency of hunter-gatherers taken as a group *as a whole* are not
306 towards any more local processing style but a more global one, observing forms in terms of overall
307 shapes rather than details (Uskul et al. 2008; Reyes-García et al. 2016), as seen in depictions of faces
308 (Segall et al. 1966). This makes sense in that overall a quick visual and cognitive appraisal is the
309 optimum strategy in a hunting and gathering context where immediate recognition of predators and
310 prey are needed (Bentley, Deregowski 1987). This doesn't mean that local processing bias and
311 attention to details rather than 'the whole' might not have carried advantages in certain specific
312 environments in the past.

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

338 marked local processing bias. Thus the differences between the two share the same features as
339 those observed between the two children with and without exceptional talent above (*figure 6*).
340 Nadia's drawing is not a photographic representation of a scene, but she has observed the details of
341 edges and forms when she saw a horse and rider, cognitively reconstructed a three-dimensional and
342 detailed form from which she interpolates edges and thus the bounding lines which she draws. A
343 typically developing child of the same age has however observed and mentally modelled a simpler
344 representation of a horse and has drawn this (without for example the three-dimensional complexity
345 needed to deal with overlapping legs). The complex mental representation of form associated with
346 local processing bias is also even seen in the drawings of a child with Asperger Syndrome who is not
347 a precociously talented artist but nonetheless shows the remarkable observation and three-
348 dimensional understanding (*figure 7*) often seen in talented art of individuals with autism (Mottron
349 and Belleville 1993).
350
351 [INSERT FIGURE 6 HERE]
352 [INSERT FIGURE 7 HERE]
353
354 Local processing bias is an explanation for some of the talents in other spheres which are associated
355 with ASC, such as those in engineering domains for example (Happé et al. 2001; Briskman et al.
356 2001). Thus the cognitive skills inherent in talents in realistic depiction are shared with other careers
357 and interests. Drake and Winner describe two children with exceptional talent at realistic depiction
358 whose analytical understanding of natural forms seem to lead them to careers in natural science
359 rather than art for example (Drake, Winner 2017). One of the authors (BW) who has run many
360 groups with children on the autism spectrum has seen numerous children over the years with
361 exceptional artistic talent go on to University or into careers in animation, art and a variety of other
362 creative endeavours. Happé and Frith further argue that the advantages of an extreme cognitive

363 focus on detail to several realms make the persistence of individuals with local processing bias
364 within the gene pool 'not hard to explain' (Happé, Frith 2006:16).
365
366 Local processing bias is a key element of autism, but is also seen in some individuals without ASC.
367 Given the association with autism, it is not surprising that exceptional talents at realistic depiction
368 are not unusual in those with Asperger Syndrome however. A conservative estimate of the
369 percentages of such individuals with exceptional talent in realistic depiction is around 6% (Mottron
370 et al. 2006) with recent research suggesting that the actual figure may be much times higher, with
371 one large study suggested that 62% have special isolated skills (Meilleur et al. 2015). In our large
372 scale study of over 1000 people carried out to better understand the relationship between
373 perception, cognition, autism and artistic talent we found that individuals with a very high autism
374 quotient (AQ) of 32 or above , which is taken as indicative of an autism spectrum condition within a
375 population sample (Baron-Cohen et al. 2001)were statistically much more likely than neurotypical
376 individuals (ie those with a lower AQ score) to have an interest in and experience of art outside of
377 any school curriculum[i]. Some element of autism thus may influence abilities or motivations to create
378 art. We also found that the attention to detail score overall (in the autism and overall population)
379 was also correlated with interest in and experience of art[ii]. A local processing bias both enables a
380 talent at realistic depiction and is associated with a heightened interest in depiction and motivation
381 to draw.
382
383 Talents at realistic depiction are not particularly unusual within the autism spectrum population and
384 are much rarer proportionately in the neurotypical population. In a study of 153 typically developing
385 children who were 6-12 years old none showed a comparable level of skill for example (Drake,
386 Winner 2013). Clearly the possibility that any individual with an exceptional talent in realistic
387 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*) [iii]. 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.

[INSERT FIGURE 8 HERE]

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).

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

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.

438

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

448

449 Zaidel comments:

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

453

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

463 prey at a distance from fragmented cues (Hodgson, Watson 2015) may also encourage a focus on
464 fine details.
465
466 The integration of individuals with local processing bias, whether seen as important through
467 technological or artistic talents, has a wider social and cultural significance. Spikins (2015) and
468 Spikins et al. (2016) argue for the wider social significance of support for individuals with disabilities
469 and vulnerabilities for example. In the case of those for whom local processing bias also brought
470 with it traits of autism, compulsive behaviour patterns or certain social difficulties, emerging roles
471 for their social and technical skills (Spikins et al. 2016) would explain the positive selection for autism
472 genes through a balance of skills and deficits. This positive selection is not surprising as our cultural
473 connotations of 'autism' might lead us to assume. Whilst some individuals with autism spectrum
474 conditions today are severely disabled (particularly those with autism with intellectual impairment),
475 a more usual pattern is that of individuals whose social abilities allow them to be fully integrated and
476 whose particular cognitive strengths allow them to fulfil significant social and technical roles.
477

478 Conclusions

479
480 There is little question that amongst the corpus of European Upper Palaeolithic art there are many
481 depictions, such as the frieze of lions at Chauvet Cave for example, which are the work of
482 exceptionally talented artists. Rather than influenced by drug use, the similarities between such art
483 and that of talented artists with autism are shown here to be a product of a cognitive condition -
484 local processing bias - which brings with it exceptional abilities to observe and cognitively
485 reconstruct forms. Local processing bias is common to those with exceptional talent in realistic
486 depiction whether associated with an autism spectrum condition or not, and is a potentially
487 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

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Figure Legends

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

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.*

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.*

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.*

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

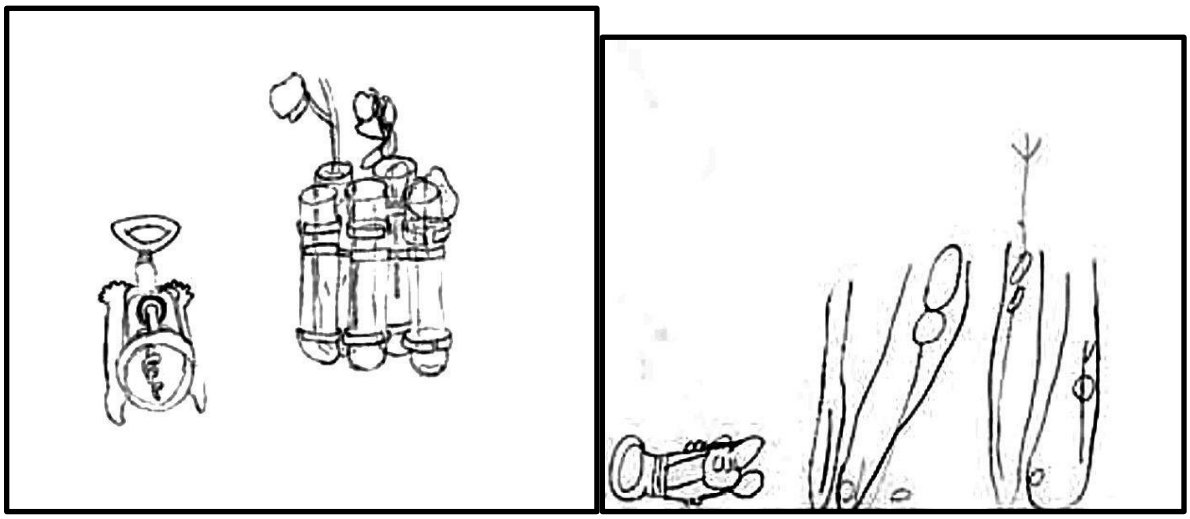
Figure 7: *Drawing of a bike by a child with Asperger's Syndrome A) at 2 years and B) at aged 4-5 years. Though this child does not have precocious drawing ability both depictions show an high level*

understanding of three-dimensional forms and how they relate to each other based on local processing bias.

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.*

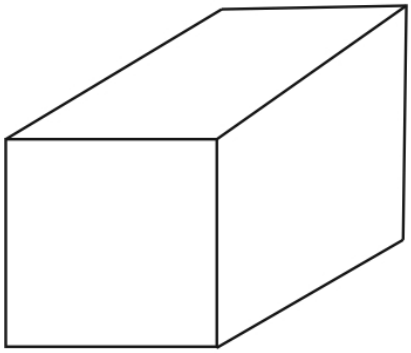
Figures

Figure 1



A) B)

Figure 2



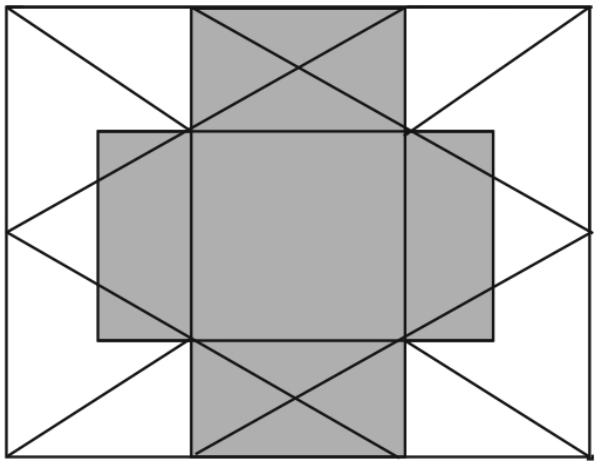


Figure 3

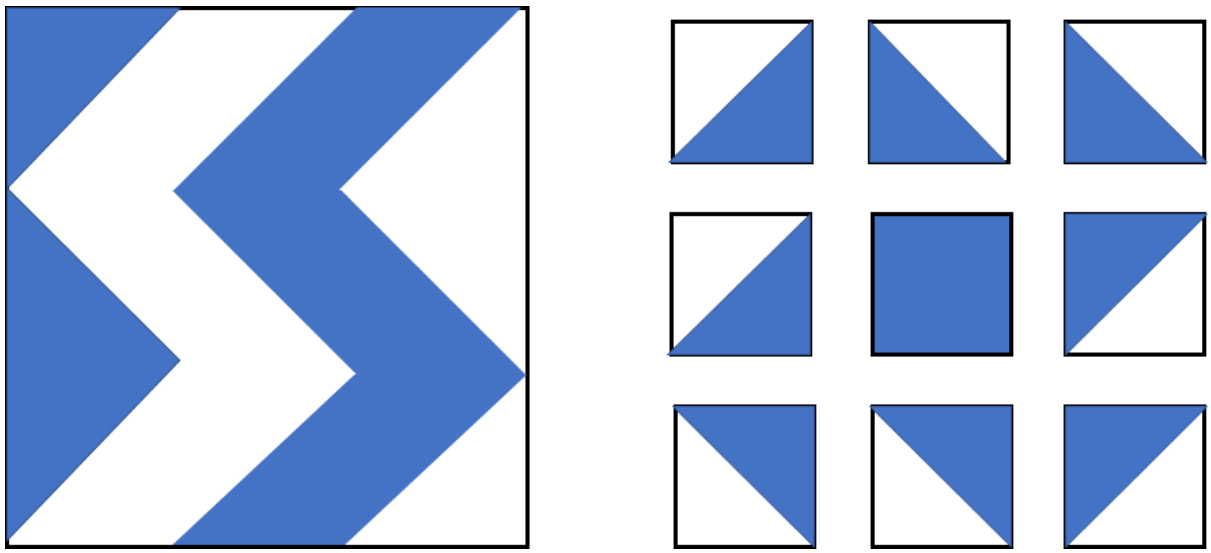
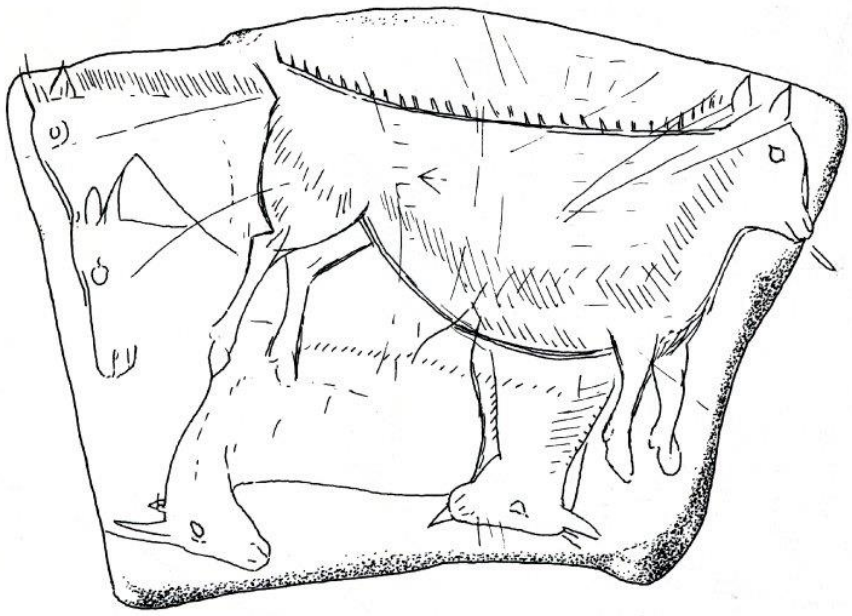
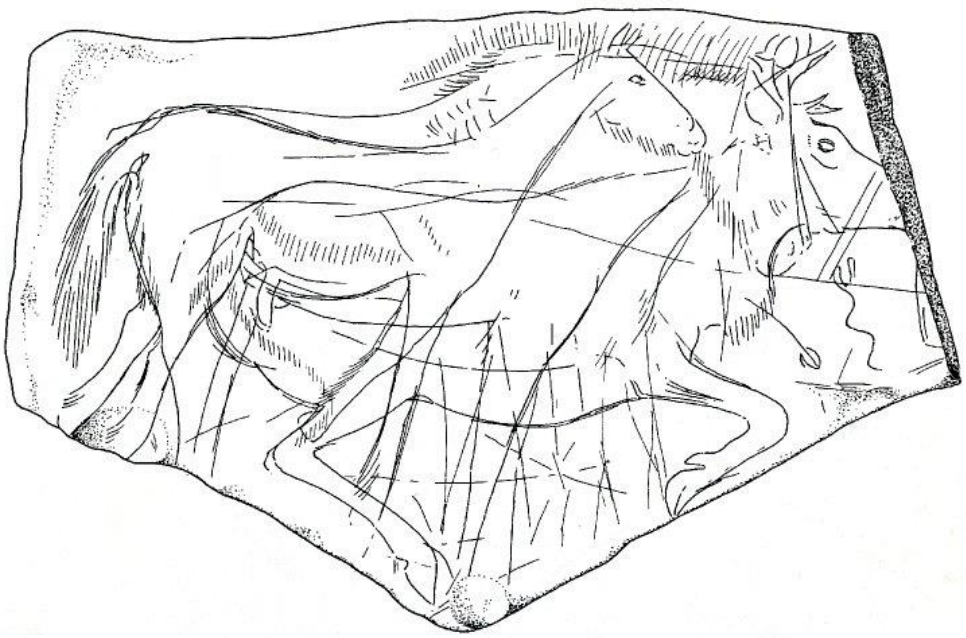


Figure 4



A)

B)



C)

Figure 5

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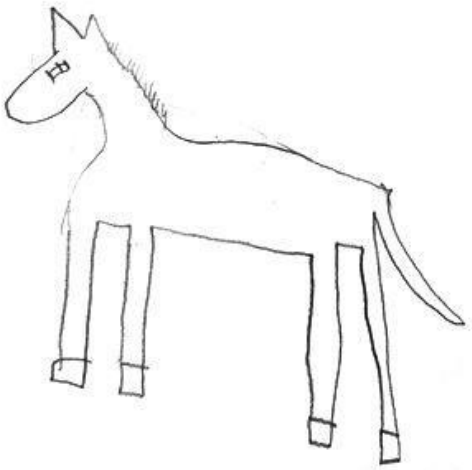

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911 *A)* *B)*
912 *Figure 6*
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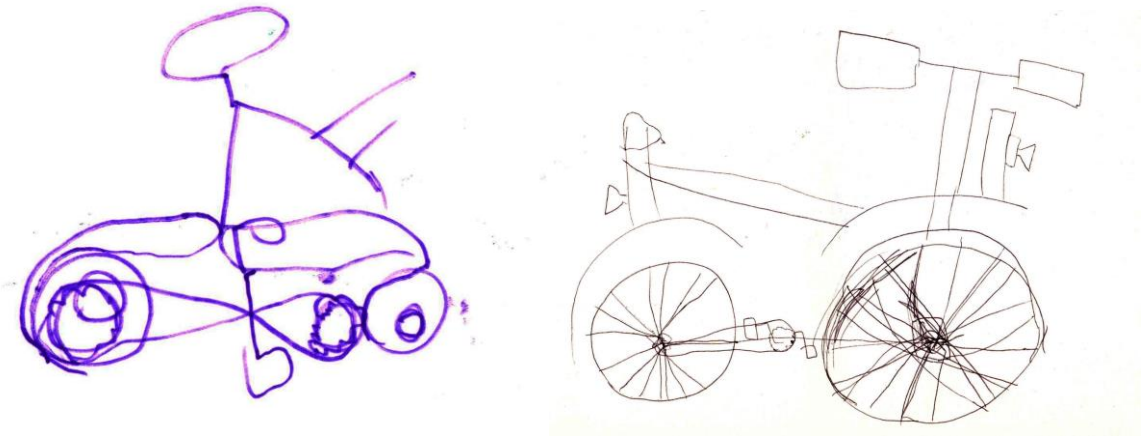

A) B)

Figure 7.

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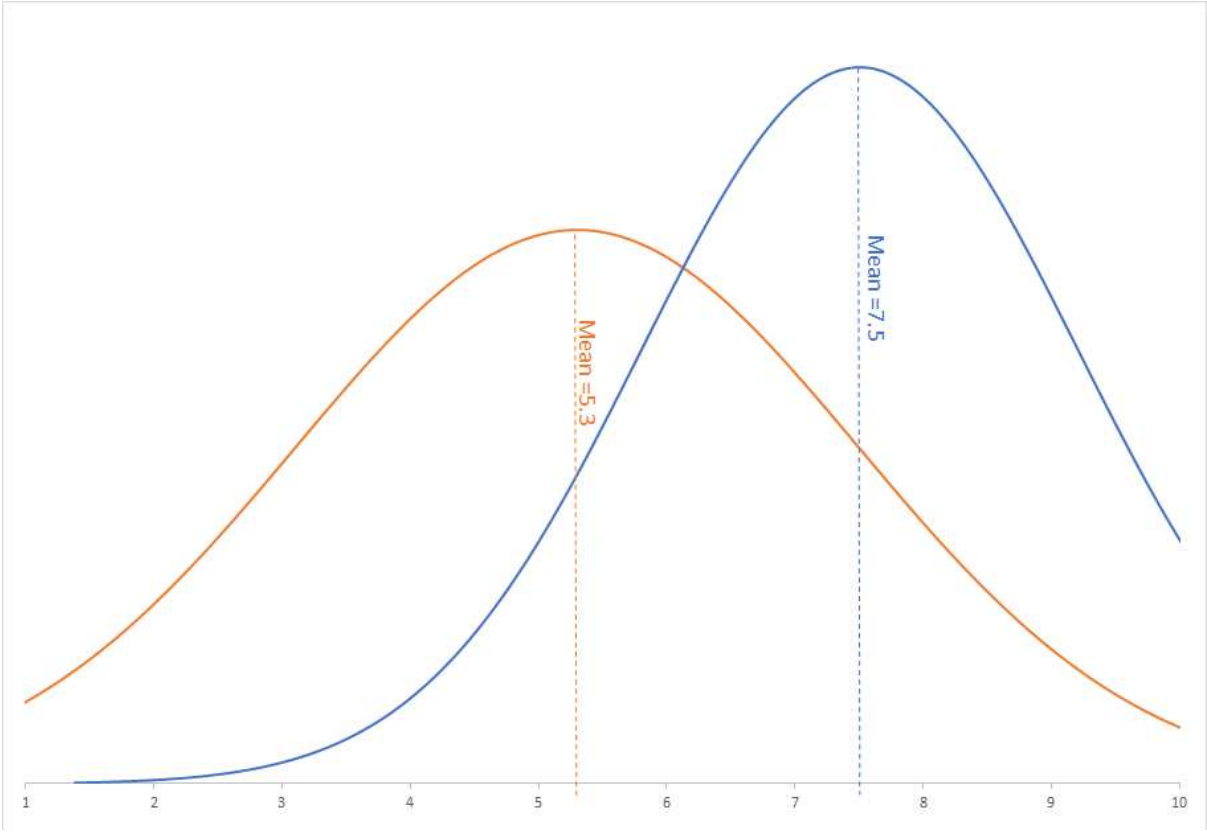

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927 *Figure 8*
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[i] Our online survey of the influence of perception and cognition on art sampled 1062 people, assessing their score on the Autism Quotient (AQ), a well tested measure of autistic 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)

[ii] 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.

[iii] 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).