# Critical Evaluation of the Concept of Autistic Creativity

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## 1. Introduction

Autism Spectrum Disorders (ASD) are neurodevelopmental conditions that are associated with an astonishing combination of cognitive strengths and weaknesses with a substantial minority of individuals displaying some exceptional creative abilities, reaching genius proportions in some rare cases. Creativity is a multifactorial construct and neuroscience is only beginning to unravel some of the cognitive components involved in the creative process. In this chapter we contrast neuroscientific evidence from creativity research with models attempting to explain talent and creativity in ASD. Although there are no agreed definitions for creativity the formulation put forward by Griffiths [1] "Creativity is a mental journey between ideas or concepts that involves either a novel route or a novel destination" (p.6) seems to fit the picture very well. Various explanations and theories have been put forward to account for creativity ranging from unconscious mechanisms, cognitive processes, special abilities and personal traits to links with genetic processes and psychopathology.

The classical portrait of autism is that of rigid, stereotyped behaviours, a preference for sameness and a resulting lack of imagination. Therefore, the prevalent view is that creativity and imaginative thought are extremely difficult or impossible for individuals with ASD. There is substantial research evidence that almost all forms of imagination are impaired in autism including lack of pretend play, pragmatic language, comprehension and construction of narrative, theory of mind and experimental tests of creativity [2-6]. A significant challenge to this perceived lack of creativity is the enormous achievements that some people with ASD show in creative and scientific fields. Some theorists and clinicians have therefore challenged the view of impoverished creativity in ASD [7-12].

In this review the focus is on a subgroup of individuals on the autistic spectrum who display exceptional creative talents and abilities. The features of ASD that favour creativity include narrow interests, great persistence, ability to see details within a whole, a fascination with facts (rather than people) and having savant type talents. While social imagination is impaired, autistic imagination of the Einsteinian type is amplified.

## 2. Nature of autistic intelligence and creativity

"Autistic intelligence" as described by Hans Asperger [13] is a sort of intelligence hardly touched by tradition and culture – "unconventional, unorthodox, strangely 'pure' and original, akin to the intelligence of pure creativity". As pointed out by Einstein "To raise new questions, new possibilities, to regard old problems from a new angle, requires imagination and makes real advance in science" [14 p. 40].

Individuals with ASD show great variation in IQ ranging from severe intellectual impairment to superior ability. In addition, intelligence as measured by traditional intelligence tests reveals a different intellectual profile in ASD than in the neurotypical population with peaks on Block Design and troughs in Comprehension that appears to be robust across IQ levels [15]. Individuals with ASD also generally display atypical cognitive processes when performing these tasks. More recent studies [16,17] revealed further evidence for a different nature of autistic intelligence including fast information processing despite poor measured IQ.

The relationship between intelligence and creativity is unclear and ranges from suggestions of totally distinct psychological entities to overlapping constructs to different labels for the same thing [18]. Guilford [19] in his 1950 landmark paper "Creativity" asserted that creative talent could not be understood in terms of "intelligence". Within the creativity literature, as noted by Lubart [20] "the dominant view is that certain intellectual abilities may be particularly useful in creative work, but no intellectual ability is devoted only to creativity" (p.288). Good general intelligence, domain-specific knowledge and special skills are necessary ingredients for creativity; however, these components alone are not sufficient for explaining creative processes [21].

Gardner's [22] model of multiple intelligences holds that intelligence is a collection of different intellectual capacities including linguistic, logical-mathematical, musical, bodily kinaesthetic, spatial intelligence and two forms of personal intelligence, - one oriented towards the understanding of other persons, the other towards an understanding of self. Autistic intelligence tends to be concentrated in the areas of music and logical-mathematical and spatial abilities. By nature, individuals with autism are extremely logical and analytical, and their thinking is concrete which makes them good mathematicians though lesser poets. The exception may be a minority of gifted individuals with ASD who have special literary talents as suggested by Ilona Roth [23] in her analysis of autism spectrum poets including Donna Williams, Tito Mukhopadhyay and Wendy Lawson. Roth makes the point that "poetry, with its dependence on intensely abstract, symbolic, and free-flowing forms of expression" (p. 161) might be particularly suited to the autistic cognitive style.

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Many features of Asperger syndrome enhance creativity, but the ability to focus deeply on a topic and to take endless pains is characteristic. Hans Asperger [24] emphasized the intensity with which special interests are pursued already in his first lecture about children with "autistic psychopathology". It appears that these unique qualities of concentration and also perception as discussed in subsequent paragraphs in individuals with ASD may give rise to extraordinary creative abilities. Exceptionally gifted people like for example the animal scientist and author Temple Grandin [25] declares that her autism, as manifested in her acute visual/spatial mind and in her powers of concentration is what has made her success possible (p.188). People with Asperger syndrome live very much in their intellects, and certain forms of creativity benefit greatly from this [26]. Apart from good concrete intelligence additional characteristics of a gifted person with ASD include, ability to disregard social conventions, unconcern about the opinions of others and a sometimes-childlike naivety and inquisitiveness.

According Nancy Andreasen [27], who made a significant contribution to research on creativity, the personality traits that characterize creative individuals include "openness to experience, adventuresomeness, rebelliousness, individualism, … persistence, curiosity, simplicity, … the ability to see things in a different and novel way, indifference to social conventions, dislike of externally imposed rules, driven by own set of rules derived from within and a childlike manner" (p.30-32). Not surprisingly, the above two descriptions are strikingly similar.

## 3. Cognitive processes involved in creativity

Creativity is a multidimensional construct and cognitive neuroscience is only beginning to understand the many cognitive components involved in creative thinking including the neural substrates underlying these processes [for a review see 28]. Theories of creativity in general suggest that creativity is linked to attentional capacity [29] and associative or divergent thinking processes [30]. Mendelsohn [31] emphasised the specific role of "defocused" attention or a widened attentional ability in highly creative individuals, which is in contrast with the extremely narrow focus of attention ascribed to individuals with autism [e.g. 32]. Likewise, divergent thinking, which involves the production of a variety of responses [33] and assumes to depend on extensively connected neural networks also conflicts with the well reported neural underconnectivity and enhanced local networks found in autism. As pointed out by Nettle [34] "different domains of creativity require different cognitive profiles, with poetry and art associated with divergent thinking, schizophrenia and affective disorder, and mathematics associated with convergent thinking and autism" (p.1). It appears that other concepts of information processing need to be considered when attempting to elucidate the specific and unique mechanisms underlying autistic creativity. In the words of Allan Snyder [35] "The fact that genius might fall within the autistic spectrum challenges our deepest notions of creativity. Are there radically different routes to creativity: normal and autistic?" (p. 1403).

The main current interpretation of special gifts and savant skills associated with autism include cognitive and psychological theories as well as various other models.

## 4. Savant syndrome and creativity

According to Treffert [36]: "Savant syndrome is a rare, but extraordinary condition in which persons with serious mental disabilities, including autistic disorder, have some 'island of genius' which stands in marked, incongruous contrast to overall handicap" (p.1351). Savant skills are found more commonly in ASD than in any other group [37] and are generally attributed to low-functioning autism but can also occur in individuals with normal and very high intelligence.

Theories put forward to explain savant skills strongly suggest a relationship with repetitive, obsessional and restricted behaviour [38]. Savants generally exhibit circumscribed interests usually within their skill area [39], which leads to considerable rehearsal, practice and training. Savant skills are also strongly associated with rote memory [40]. Pring [41] in her analysis of memory characteristics in savants argued against the rote memory explanation and instead proposed the existence of complex long-term memory structures in savants. In general, memory is considered an essential cognitive component of savant skills. In addition, researchers have suggested a role for 'implicit' or unintentional, learning in savant skill development [42,43]. Results of neuropsychological examinations of a calendar-calculating savant indicated that good memory, superior mental calculation and knowledge of calendar are the underlying elements for this specific talent [44]. Taken together, the classical portrait of the autistic savant is largely imitative and not very creative and some writers [e.g. 45] argued that true creativity is missing in savants "there are no savant geniuses about…. Their mental limitations disallow and preclude an awareness of innovative developments" (p. 177). In contrast, other theorists [46,47] believe that savants, particularly those with Asperger syndrome with above average intelligence levels [48] can be extremely creative. Mottron et al [49] write that "Savant performance cannot be reduced to uniquely efficient rote memory skills …. and encompasses not only the ability for strict recall, requiring pattern completion, but also the ability to produce creative, new material within the constraints of a previously integrated structure" (p.1388).

Various pathological conditions such as frontotemporal dementia, dominant-hemisphere strokes, head injuries and infections may also result in the emergence of savant like abilities [e.g. 50]. Of particular interest is the fact that individuals with these diverse types of disorders and emerging savant skills also develop cognitive features and behavioural traits, which are characteristic of autism [51].

## 5. Cognitive and psychological theories and explanations underlying special gifts and talents and savant skills in ASD

The development of special gifts and talents in ASD has been associated in general with the ability to process local information. These abilities include detail-focused cognitive style (weak coherence) [52], enhanced perceptual functioning [53], an accentuated capacity for systemizing [54], privileged access to low-level perceptual processes [55] and various other psychological and physiological states.

### 5.1. Weak central coherence

A different cognitive style, the weak central coherence theory (WCC) proposed by Uta Frith [56] and Frith and Happé [57] has been suggested as an explanation for certain special abilities found in ASD. This exceptional part-based processing style is demonstrated in the superior ability individuals with ASD show on tasks such as block design and embedded figures resulting from deficits in integration processes that serve to draw information together as a meaningful whole [see 58]. According to Frith [59], the WCC particularly addresses the special gifts and talents and acute perceptual abilities in autism (e.g. hypersensitivity, visual and auditory abilities) and can explain the achievements of individuals with ASD syndrome in art, science, music, and many other areas. Local coherence, which is defined by close attention to mechanical or physical patterns, is exemplified in the work of Temple Grandin [60]. Atypical attentional mechanisms and abnormal neural connectivity have been suggested as possible cognitive and neural mechanisms underlying WCC.

### 5.2. Enhanced perceptual functioning

Also located at the level of perception is the model proposed by Mottron and Burack [61] and Mottron et al [62] which are based on enhanced perceptual functioning (EPF) suggesting that people with autism have an overdevelopment of low-level perceptual abilities at the expense of high-level processing mechanisms. This theory provides a convincing account of special abilities in ASD such as peaks of ability in visual and auditory modalities and also indicates that a variety of cognitive processes are required for the development of savant abilities. For example, Mottron et al [63] propose that enhanced detection of patterns, including similarity within and among patterns is contributing to creativity evident in savants. As far as neural correlates for their theory is concerned the authors suggest the notion of brain plasticity and an overfunctioning of brain regions involved in perception in autism [64].

EPF and WCC are similar in emphasizing detail focused processing bias and superior local processing. Superiority in local coherence may be specific to autistic creativity and as argued by Mills [65] "produces an imaginative faculty defined by close attention to mechanical or physical patterns not psychological or social rules" (p.126).

### 5.3. Systemizing theory

This above interpretation appears to be in line with the "systemizing theory" put forward by Baron-Cohen et al. [66] which emphasises the superior ability in recognizing repeating patterns in stimuli (e.g. numerical, spatial, mechanical, auditory systemizing). The "systemizing theory", in contrast to the WCC model, predicts that individuals with ASD have a strong central coherence as indicated by their excellent skills in integrating information in areas such as astronomy and physics. This ability, however, does not apply to non-systemizable fields such as fiction. Similar to the WCC the systemizing model also posits excellent attention to detail in perception and memory. Baron-Cohen et al [67] further suggest that this excellent attention to detail is a consequence of sensory hypersensitivity found in individuals with ASD. Belmonte et al [68] posited that local overconnectivity in the posterior sensory parts of the cortex is responsible for the sensory 'magnification' in ASD.

### 5.4. Low level information processing

The work of Synder et al. [69] also provides an understanding of certain forms of creativity. According to Snyder and Mitchell [70] outstanding savant skills might be accomplished by accessing early stages of information processing. Their controversial model predicts the possibility of accessing non-conscious information by artificially disinhibiting the inhibiting networks associated with concept formation, using transcranial magnetic brain stimulation (TMS). By means of this method Snyder et al. [71] propose that this process will open "the door for restoration of perfect pitch, for recalling detail... and even enhancing creativity". A recent EEG study [72] attributing increased visual detail perception in autism to neural abnormalities related to low-level visual processing potentially supports this theory.

Snyders's theory [73] furthermore suggests the possibility that savant skills may be latent in everyone, but a "form of cortical disinhibition or atypical hemispheric imbalance" is required in order to access them (p. 1399). In support for his theory Snyder quotes the emergence of savant skills in individuals without any previous history for talents due to a variety of illnesses.

Snyder's model explains many of the talents and characteristics associated with Asperger geniuses including their childlike view of the world and lack of preconceptions, which is beneficial for developing new and original theories and perspectives. For example, Ludwig Wittgenstein, who had Asperger syndrome did spend little time reading other philosophers and felt most of them were wrong anyhow. He didn't want to "cloud his mind with false theories" [74].

### 5.5. Primary process thought and disinhibition syndrome, reduced self-awareness – 'Flow'

Theories of creativity [75, 76] also highlight the importance of primary process thought as found in dreaming, free association and psychosis in creative processes. Einstein suggested that creative scientists are the ones with "access to their dreams. Occasionally, a dream will actually provide the solution to a problem", as cited by Gregory [77] (p.226). Many mathe-

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maticians are intuitive thinkers and rely on the unconscious mind to a large extent, like for example the genius mathematician Poincarė [78]. Freudian theory holds that primary processes or primitive thinking which creative persons have more access to are based on their weak defence mechanisms of repression. Individuals with Asperger syndrome have very weak defence mechanisms thus allowing them access to early childhood memories [79].

Low levels of repression or inhibition are associated with creativity and a number of theorists [80, 81] have suggested that creativity is "a disinhibition syndrome", i.e. highly creative individuals lack cognitive inhibition. Neural correlates of cognitive disinhibition are the frontal lobes and research indicates that creative individuals show less frontal-lobe activity during verbal association tasks [82]. Deficits in inhibition have been documented in autism [83] as well as in Attention Deficit Hyperactivity Disorder (ADHD) [84] a neurodevelopmental disorder that is associated with increased creativity.

Also relevant in this context maybe the concept of "flow" proposed by the psychologist Csíkszentmihályi [85]. The notion of "flow" indicates a familiar state of reduced self-awareness where temporal concerns (time, food, ego-self, etc) are ignored during periods where the individual is fully immersed in a task or process. According to Csíkszentmihályi "flow" is characterised by a feeling of great absorption, engagement and fulfilment and thought to be inherently reinforcing and rewarding [86]. As alerted to in the chapter "Atypical Sense of Self in Autism Spectrum Disorders: A Neuro-cognitive Perspective" (this book) [87] diminished self-awareness which is a characteristic of individuals with ASD and associated with right hemisphere dysfunction might be advantageous in the development of special talents in ASD as quoted by Happé and Vital [88] (p.1373).

To conclude, although no single theory can explain the cognitive mechanisms underlying savant skill development, prodigious memory, atypical perception and excellent attention to detail are fundamentally associated with savant like talents in individual with ASD.

## 6. Neural basis of creativity in non-clinical populations

The study of the neural basis of creativity is an area greatly neglected by scientific research and despite methodological difficulties associated with investigating creativity any account of creativity must include explanations about the neural correlates of creativity [89].

Neuroscientific approaches aiming to determine the physiological basis of creative thought, are assuming that creativity is a measurable trait. Creativity can be interpreted as physiological changes that are required for creative problem solving focussing on EEG measures of cortical activation [90]. Theories of creativity in general postulate that low levels of cortical activation contribute to creative inspiration. Imaging data [91] suggest that great creativity not only requires a high level of specialized knowledge (stored in temporal and parietal lobes) and divergent thinking (mediated by the frontal lobes) but also co-activation and communication between areas of the brain that normally do not show strong connections. Highly creative individuals also possess the ability to modulate neurotransmitters [92, 93] such as the norepinephrine system (located in the frontal lobes), indicated by a reduction of cerebral levels of norepinephrine during creative periods. Support for the role of frontal areas in a fluid analogy-making task comes from an fMRI study [94] indicating bilateral neural activations. A study measuring differences in cerebral blood flow between highly creative individuals and controls during a verbal task of creative thinking [95] implicated a neural network consisting of right and left fronto-temporal, parietal, and cerebellar regions in highly creative performances. These areas are involved in cognition, emotion, working memory and response to novelty.

## 7. Neural basis of creativity in ASD

We are not aware of any studies investigating directly the neural basis of creativity in autism apart from studies exploring savant skills in autism. Some of these support the Left Hemisphere (LH) dysfunction/ and Right Hemisphere (RH) compensation theory [e.g. 96] as indicated by hemispheric asymmetry. Research evidence of neuroanatomical abnormalities including atypical minicolumnar organization in ASD [97,98] as well as neural hypotheses about abnormal connectivity [e.g. 99] support this theory.

### 7.1. Hemispheric asymmetry

Cerebral asymmetry refers to the lack of structural symmetry in left and right hemispheres in humans. Atypical cerebral asymmetry, a deviation from the normal pattern of cerebral asymmetry has been associated with special cognitive talents [100] and creativity [101] as cited by Smalley et al. [102]. For example, the capability for making distal or global verbal associations is one factor contributing to creativity and according to Brugger and Graves [103] the basis for this type of verbal creativity is “cerebral laterality in which an individual has a relative weakening of left hemisphere dominance and strengthening of availability of right hemisphere processing” [104] p. 138.

Atypical cerebral asymmetry has been associated with autism, dyslexia and ADHD [105], neurodevelopmental disorders considered to share regions of linkage overlap [106]. In addition, creativity in psychiatric populations is often associated with atypical cerebral asymmetry [107] and a RH “bias” [108].

Research evidence for atypical cerebral asymmetry in autism (e.g. increased size of some RH cortical structures) and reversed lateralization of language has been well documented [e.g. 109]. An imaging study by Herbert et al [110] found a “sizeable right-asymmetry increase” in subjects with autism. Individuals with autism had twice as much right-as left-asymmetrical cortex than the control sample. This finding was interpreted as a consequence of early abnormal brain growth abnormalities. According to the hypothesis put forward by Geschwind and Galaburda [111] the immaturity of the LH in utero makes it more susceptible to damage, which could result in a compensatory overdevelopment of the RH caused by neural migration and thus resulting in an anomalous RH-dominance. As the RH develops earlier than the LH, accelerated early brain development in autism may lead to anomalous lateralization of cognitive functions as suggested by Herbert et al [112].

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### 7.2. Right hemisphere processing and creativity

Savant skills are linked to the RH [113], which is dominant for attention, visuospatial and emotional function. Various authors [114-115] have suggested that autistic savants have atypical LH dysfunction with RH compensation. Based on research evidence including imaging studies Treffert [116] speculated that "one mechanism in some savants, whether congenital or acquired is left brain dysfunction with right brain compensation." The notion of "paradoxical functional facilitation" as described by Kapur [117] denotes loss of function in one damaged brain area and enhanced function of another area, which as emphasized by Treffert is "central to explaining savant syndrome" (p.1356).

RH skills can be characterized as non-symbolic, artistic, concrete and directly perceived in contrast to LH skills that are more sequential, logical, and symbolic. For example musical, artistic, visual or spatial abilities (mathematics) are primarily RH skills.

The association between RH and creativity is based on research evidence demonstrating that the RH is more involved in production of mental images than the LH, perception and production of music, e.g. the right inferior frontal gyrus is known to be involved in musical pitch encoding and melodic pitch memory [118]. EEG studies show that highly creative individuals show more right than left-hemisphere activation during experimental studies [119], indicating that during the creative process creative individuals rely more on the RH. Lesion studies as well as unimpaired population studies have demonstrated that the RH is superior to the LH at noticing anomalies in objects [120]. Individuals with autism are well known for detecting even the smallest changes in the environment.

In sum, several lines of evidence suggest that atypical cerebral asymmetry which is a highly heritable trait [121] is associated with autism and linked to certain aspects of creativity. It is also likely that some of the structural brain abnormalities evidenced in autism are related to the special cognitive functioning that encourages great creativity. Neurological brain differences have been reported in the literature on creativity [122].

### 7.3. Neuroanatomical abnormalities in autism

Converging neuroscientific evidence has suggested that the neuropathology of ASD is widely distributed, involving impaired connectivity throughout the brain. Neuroanatomical abnormalities in autism include increase in cortical thickness [123], and increase in head and brain size [124]. Accelerated growth in brain size in early childhood in autism has been documented by a range of studies [125], which may be consistent with the asymmetric cerebral lateralization in autism as discussed above. The increased brain volumes in autism are believed to be the result of insufficient or abnormal prenatal pruning, which together with genetic factors are most likely to underlie these growth abnormalities [126]. In addition, there is evidence of higher birth weight [127] and faster body growth [128] as well as increased levels of growth hormones [129] in autism. These altered brain growth rates are considered to have a strong influence on patterns of brain connectivity and cerebral lateralization [130, 131] and differential cognitive functioning. For example, the increased hippocampus size in autism [132] may be associated with enhanced visual-spatial, mathematical and mechanistic processing in autism as well as savant abilities such as calculation and memory. Imaging data of a reduced size of corpus callosum in autism [133] is consistent with the reduced interhemispheric brain connectivity reported in autistic individuals [134]. Neural underconnectivity [e.g. 135] provides support for the weak "central coherence theory" which postulates enhanced local and decreased global information processing in autism. Research on patterns of cortical connectivity also indicates that a specific minicolumnar phenotype found in autism may be beneficial for information processing and/or focused attention and may also offer an explanation for the savant abilities autism [136, 137].

To conclude, although neural mechanisms underlying savant skill and development are not well established, associating creativity with hemisphere lateralization and anatomical abnormalities in autism is supported by empirical evidence and also has some explanatory potential. Additional areas to explore are genetic factors and creativity found in other pathological conditions.

## 8. Nature versus nurture

Is great creativity a fortunate combination of specific traits, or do "creativity genes" exist? As speculated by Smalley et al [138] "genes that increase one's risk for certain psychiatric or learning disorders may also be 'enhancer' genes for creativity (and intuition)" (p.82). According to Gardner [139] it is extremely unlikely that there is such a thing as a "poetry gene or a music gene" since complex human behaviours typically have a "polygenic basis" (p. 175). Without doubt ASD have a polygenic basis and genetic factors not only contribute to specific skills but also to traits such as persistence, the capacity for concentration for extended periods, and curiosity about certain types of stimulation. Lykken et al [140] describe the concept of *emergenesis*, an extreme form of epitasis, in which a unique combination of genes may lead to qualitative shifts in capacity or ability that may apply to extremely gifted individuals with ASD.

The relationship between inherited talent and/or extensive practice is a very contentious aspect of superior ability in specific skills. The view propounded by Howe [141] emphasizing the overwhelming role of practice in the acquirement of special skills, is largely rejected by a majority of theorists who argue for the role of innate talent [142-144]. Special talents are essentially innate in predisposing to cognitive or physical qualities and are the key to understanding geniuses from Einstein to Mozart [145]. For example, research evidence from twin data [146] suggests a genetic basis for detail-focused cognitive style predisposing to talent in ASD. It is configuration of genes and variations in genetic inputs that are critical to the success in persons of great creativity. It is our belief that there are significant genetic underpinnings to creativity of genius proportions, which of course could not be expressed without environmental factors.

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## 9. Novelty, ADHD and creativity

The majority of theoretical conceptions of creativity agree that the main component of creativity is its novelty, uniqueness or unusualness that undoubtedly applies to the creativity displayed by gifted individuals with ASD. Novelty or sensation seeking behaviour is also strongly associated with ADHD. A significant degree of comorbidity between autism and ADHD has been documented [e.g. 147] in the literature. Although reported to have poor attention and concentration and being poor academic performers individuals with ADHD have a capacity to hyperfocus, which allows them to produce great works of art. For example the poetry of Lord Byron, who had ADHD [148] is an example for a work of genius in this area. As pointed out above, both autism and ADHD are associated with atypical cerebral asymmetry which is a highly heritable and complex phenotype linked to creativity and sharing regions of linkage overlap [149,150].

## 10. Psychopathology

There is a very close relationship between creativity (especially in literature and arts) and psychopathology, particularly mood disorder [151, 152]. An association of biochemical factors in psychosis and creativity has been suggested by Folley et al [153] indicating the noradrenergic system. This model also provides possible links between attention, divergent thinking, and arousal based on mechanisms that interact with structural and neurochemical systems of the brain and has the potential to explain the novelty seeking behaviour implicated in ADHD but may have less explanatory power as far as autism is concerned. According to Sternberg and Lubart [154] creativity and novelty must be coupled with appropriateness for something to be considered creative. Although schizotypal thought most likely leads to an increase in novel ideas, they may not always be appropriate.

In contrast, the nature of creativity displayed by individuals with ASD is associated with the distinctiveness of the autistic brain and its unique neural connectivity. In this context Temple Grandin [155] has stated, "it is likely that genius is an abnormality" (p178-179). However, she also believes that autistic intelligence is necessary in order to add diversity and creativity to the world: "It is possible that persons with bits of these traits are more creative, are possibly even geniuses…If science eliminated these genes, maybe the whole world would be taken over by accountants" (p.124).

## 11. Conclusion

The results of our evaluation suggest that many features of ASD are advantageous for great creativity. Creativity is an extremely complex and multifaceted construct and no cognitive theory or model of brain function has so far been able to fully account for it. We suggest that the distinctive gifts of perception, attention, memory and information processing combined with personality attributes can give rise to the extraordinary creativity seen in some individuals with ASD. It is our view that progress in elucidating the neural basis of autism may hold promises for a better understanding of autistic creativity and creativity in general. Autism Spectrum Disorders are mainly portrayed as negative phenomena, as a curse, but if they were an integral part of the mindset of highly creative individuals such as Einstein and Darwin who possessed autistic traits they could be regarded in some aspects as a gift [156].

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## References

[1] Griffiths TD. Scientific Commentary. Capturing Creativity. Brain 2008;131: 6-7.

[2] Baird G, Cox A, Charman, T, Baron-Cohen S. et al. A Screening Instrument for Autism at 18 Months of Age: A Six-Year Follow-up Study. Journal of the American Academy of Child and Adolescent Psychiatry 2000; 39: 694-702.

[3] Happé F. Communicative Competence and Theory of Mind in Autism: A Test of Relevance Theory. Cognition 1993;48: 101-119.

[4] Bruner J, Feldman C. Theories of Mind and the Problem of Autism. In: Baron-Cohen S, Tager-Flusberg H, Cohen DJ. (eds) Understanding Other Minds: Perspectives from Autism. Oxford: Oxford University Press; 1993. p 267-291.

[5] Baron-Cohen S. Theory of Mind and Autism: a Review. Special Issue of The International Review of Mental Retardation 2001; 23: 169.

[6] Craig J, Baron-Cohen S. Creativity and Imagination in Autism and Asperger Syndrome. Journal of Autism and Developmental Disorders 1999;29: 319-326

[7] Fitzgerald M. Autism and Creativity: Is there a link between autism in men and exceptional ability? New York: Brunner Routledge; 2004.

[8] Fitzgerald M. The Genesis of Artistic Creativity. London: Jessica Kingsley; 2005.

[9] Fitzgerald M, James I. The Mind of the Mathematician. Baltimore: John Hopkins Press; 2007.

[10] Sacks O. An Anthropologist on Mars: Seven Paradoxical Tales. New York: Knopf; 1995.

[11] Treffert DA. The savant syndrome: an extraordinary condition. A synopsis: past, present, future. In: Happé F, Frith U. (eds.) Autism and talent. Philosophical transactions of The Royal Society 2009; vol. 364 (1522) p1351-1358.

[12] Mottron L, Dawson M, Soulières I. Enhanced perception in savant syndrome: patterns, structure and creativity. In: Happé F, Frith U. (eds.) Autism and talent. Philosophical transactions of The Royal Society 2009; vol. 364 (1522) p1385-1392.

[13] Asperger H. Die autistischen Psychopathen im Kindesalter. Archiv fuer Psychiatrie und Nervenkrankheiten 1944;11: 76-136.

[14] Jay E. Problem finding: understanding its nature and mechanism. Qualifying paper, Harvard Graduate School of Education, Cambridge, M.A.; 1989.

[15] Lincoln AJ, Allen MH, Kilman A. The assessment and interpretation of intellectual abilities in people with Autism. In: Schopler E, Mesibov GB (eds.). Learning and cognition in autism. New York: Plenum Press; 1995. p89-117.

[16] Dawson M, Soulieres I, Gernsbacher MA, Mottron L. The level and nature of autistic intelligence. Psychological Science 2007;18: 657-662.

[17] Scheuffgen K, Happé F, Anderson M, Frith U. High 'intelligence,' low 'IQ' Speed of processing and measured IQ in children with autism. Developmental Psychopathology 2000;12: 83-90.

[18] Sternberg RJ, O'Hara LA. Intelligence and Creativity. In: Sternberg RJ. (ed.) Handbook of Intelligence. Cambridge: Cambridge University Press; 2000.

[19] Guilford JP. Creativity. American Psychologist 1950;5: 444-454.

[20] Lubart T. In Search of Creative Intelligence. In: Sternberg J, Lautrey J, Lubart TI (eds.) Models of intelligence: international perspectives. Washington: APA; 2004.

[21] Heilman KM, Nadeau SE, Beversdorf DO. Creative Innovation: Possible Brain Mechanism. Neurocase 2003;9: 369-379.

[22] Gardner H. Frames of mind: The theory of multiple intelligences. New York: Basic; 1983.

[23] Roth I. Imagination and the Awareness of Self in Autistic Spectrum Poets. In: Osteen M. (ed.) Autism and Representation. New York: Routledge; 2008.

[24] Asperger H. Das psychisch abnorme Kind. Wiener Klinische Wochenzeitschrift 1938;49: 1314-1317.

[25] Grandin, T. Thinking in Pictures: and Other Reports from my Life with Autism. New York: Doubleday; 1995.

[26] Fitzgerald & James, 2007.

[27] Andreasen NC. The Creating Brain. The Neuroscience of Genius. New York: Dana Press; 2005.

[28] Abraham A, Windmann S. Creative cognition: The diverse operations and the prospect of applying a cognitive neuroscience perspective. Methods 2007; 22: 38-8.

[29] Mendelsohn GA. Associative and attentional processes in creative performance. Journal of Personality 1976;44: 341-369.

[30] Guilford JP. The nature of human intelligence. New York: McGraw-Hill; 1967.

[31] Mendelsohn 1976.

[32] Townsend J, Courchesne E. Parietal damage and narrow 'spotlight' spatial attention. Journal of Cognitive Neuroscience 1994;6: 220-232.

[33] Torrance EP. The Torrance Tests of Creative Thinking: Technical-norms manual. Bensenville, IL: Scholastic Testing Service; 1974.

[34] Nettle D. Schizotypy and mental health amongst poets, visual artists, and mathematicians. Journal of Research in Personality 2006;40: 876-890.

[35] Snyder A. Explaining and inducing savant skills: privileged access to lower level, less-processed information. In: Happé F, Frith U. (eds.) Autism and talent. Philosophical transactions of The Royal Society 2009; vol. 364 (1522) p1399-1406.

[36] Treffert 2009.

[37] Howlin P, Goode S, Hutton J, Rutter M. Savant skills in autism: psychometric approaches and parental reports. In: Happé F, Frith U. (eds.) Autism and talent. Philosophical transactions of The Royal Society 2009; vol. 364 (1522) p1369-1368.

[38] O'Connor N, Hermelin B. Talents and preoccupations in idiot-savants. Psychological Medicine 1991;21: 959-964.

[39] O'Connor & Hermelin, 1991.

[40] Hill AL. Savants: Mentally retarded individuals with special skills. In Ellis N. (ed.) International review of research in mental retardation. New York: Academic Press; 1978. (9) p277-298.

[41] Pring L. Memory characteristics in individuals with savant skills. In: Boucher J, Bowler D. (eds.) Memory in Autism. Cambridge: Cambridge University Press; 2008.

[42] Treffert D. Extraordinary people: understanding 'idiot savants'. New York: Harper and Row; 1989.

[43] Hermelin B. Bright splinters of the mind: a personal story of research with autistic savants. London: Jessica Kingsley Press; 2001.

[44] Wallace GL, Happé F, Giedd JN. A case study of a multiply talented savant with an autism spectrum disorder: neuropsychological functioning and brain morphometry.

http://dx.doi.org/10.5772/54465

In: Happé F, Frith U. (eds.) Autism and talent. Philosophical transactions of The Royal Society 2009; vol. 364 (1522) p1425-1432.

[45] Hermelin 2001.

[46] Treffert 2009.

[47] Mottron, Dawson & Soulières 2009.

[48] Fitzgerald 2005.

[49] Mottron, Dawson & Soulières 2009.

[50] Seeley WW, Matthews BR, Crawford RK, Gorno-Tempini ML, Foti D, Mackenzie IR, Miller BL. Unravelling Boléro: progressive aphasia, transmodal creativity and the right posterior neocortex. Brain 2008;131: 39-49.

[51] Heaton P. Wallace GL. Annotation: The savant syndrome. Journal of Child Psychology and Psychiatry 2004;45: 899-911.

[52] Frith U, Happė F. Autism: beyond "theory of mind". Cognition 1994;50: 115-132.

[53] Mottron, Dawson & Soulières 2009.

[54] Baron-Cohen S, Ashwin E, Ashwin C, Tavassoli T, Chakrabarti B. Talent in autism: hyper-systemizing, hyper-attention to detail and sensory hypersensitivity. In: Happé F, Frith U. (eds.) Autism and talent. Philosophical transactions of The Royal Society 2009; vol. 364 (1522) p1377-1384.

[55] Snyder AW, Mitchell DJ. Is integer arithmetic fundamental to mental processing? the mind's secret arithmetic. London: Proceedings of the Royal Society 1999;266: 587-592.

[56] Frith U. Autism: Explaining the Enigma. Oxford: Blackwell; 1989.

[57] Frith & Happė 1994.

[58] Happé F, Frith U. The Weak Coherence Account: detail-focused Cognitive style in Autism Spectrum Disorders. Journal of Autism and Developmental Disorders 2006;36: 5-25.

[59] Frith, U. (2004). Emanuel Miller lecture: Confusions and controversies about Asperger Syndrome. Journal of Child Psychology and Psychiatry 2004;45: 672-686, p. 680.

[60] Grandin 1995.

[61] Mottron L, Burack JA. Enhanced perceptual functioning in the development of autism. In: Burack JA, Charman T, Yirmiya N, Zelazo PR. (eds.) The development of autism: Perspectives from theory and research. New Jersey: Lawrence Erlbaum; 2001.

[62] Mottron L, Dawson M, Soulières I, Hubert B, Burack J. Enhanced Perceptual functioning in Autism: An Update, and eight Principles of Autistic Perception. Journal of Autism and Developmental Disorders 2006;3: 27-43.

[63] Mottron, Dawson & Soulières 2009.

[64] Mottron & Burack 2001.

[65] Mills B. Autism and the Imagination. In: Osteen M. (ed.) Autism and Representation. New York: Routledge; 2008.

[66] Baron-Cohen S, Richler J, Bisarya D, Gurunathan N, Wheelwright S. The systemizing quotient: an investigation of adults with Asperger syndrome or high-functioning autism and normal sex differences. In: Frith U, Hill E. (eds.) Autism: Mind and Brain. Oxford: Oxford University Press; 2004. p161-186.

[67] Baron-Cohen et al. 2009.

[68] Belmonte MK, Allen G, Beckel-Mitchener A, Boulanger LM, Carper RA, Webb SJ. Autism and abnormal development of brain connectivity. Journal of Neuroscience 2004;24: 9228-31.

[69] Snyder AW, Bossomaier T, Mitchell DJ. Concept Formation: Object Attributes Dynamically Inhibited from Conscious Awareness. Journal of Integrative Neuroscience 2004;(3) 1: 31–46.

[70] Snyder & Mitchell 1999.

[71] Snyder et al 2004.

[72] Vandenbroucke MWG, Scholte HS, van Engeland H, Lamme VAF, Kemner C. A neural substrate for atypical low-level visual processing in autism spectrum disorder. Brain 2008, 131(4): 1013-1024.

[73] Snyder 2009.

[74] Fitzgerald 2004.

[75] Freud S. Creative writers and daydreaming. In: Strachey J. (ed. & trans.) Standard edition of the complete psychological works of Sigmund Freud. London: Hogarth Press; 1959. (9) p141-153.

[76] Kris E. Psychoanalytic explorations in art. New York: International Universities Press; 1952.

[77] Gregory FL. The Oxford Companion to the Mind. Oxford: Oxford University Press; 2004.

[78] Fitzgerald & James, 2005.

[79] Lyons V, Fitzgerald, M. Early Memory and Autism. Letter to the Editor. Journal of Autism and Developmental Disorders 2005;35: 683.

[80] Eysenck H. Genius: The natural history of creativity. Cambridge: Cambridge University Press; 1995.

[81] Martindale C. Personality, situation, and creativity. In: Glover JA, Running RR, Reynolds CR (eds.) Handbook of creativity. New York: Plenum; 1989. p211-228.

[82] Hudspith S. The neurological correlates of creative thought. Unpublished PhD. Dissertation, University of Southern California, Los Angeles, CA; 1985.

[83] Johnson KA, Robertson IH, Kelly SP. et al. Dissociation in performance of children with ADHD and high-functioning autism on a task of sustained attention. Neuropsychologia 2007;45: 2234-2245.

[84] Ozonoff, S. Components of executive function in autism and other disorders. In: Russell J. (ed.) Autism as an Executive Disorder. Oxford: Oxford University Press; 1997.

[85] Csíkszentmihályi M. Flow: the psychology of optimal experience. Ney York: Harper and Row; 1990.

[86] Csíkszentmihályi M, Lefevre J. Optimal experience in work and leisure. Journal of Personal and Social Psychology 1989;56: 815-822.

[87] Lyons V, Fitzgerald M. Atypical Sense of Self in Autism Spectrum Disorders: A Neuro-cognitive Perspective. In: ………..

[88] Happé F, Vital P. What aspects of autism predispose to talent? In: Happé F, Frith U. (eds.) Autism and talent. Philosophical transactions of The Royal Society 2009; vol. 364 (1522): p1369-1376.

[89] Zeki S. Essays on science and society. Artistic creativity and the brain. Science 2001;293: 51-2.

[90] Martindale C. Creative imagination and neural activity. In: Kunzendorf R, Sheikh A. (eds.) Psychophysiology of mental imagery: Theory, research, and application. Amityville, NY: Baywood; 1990. p89-108.

[91] Heilman, Nadeau & Beversdorf, 2003.

[92] Beversdorf DQ, Hughes JD, Steinberg BA, Lewis LD, Heilman KM. Noradrenergic modulation of cognitive flexibility in problem solving. Neuroreport 1999;10: 2763-7.

[93] Folley BS, Doop ML, Park S. Psychoses and creativity: is the missing link a biological mechanism related to phospholipids turnover? Prostaglandins, Leukotrienes and Essential Fatty Acids 2003;69: 467-476.

[94] Gaeke JG, Hansen PC. Neural correlates of intelligence as revealed by fMRI of fluid analogies. Neuroimage 2005;26: 555-64.

[95] Chavez-Eakle RA, Graff-Guerrero A, Garcia-Reyna JC, Vaugier V, Cruz-Fuentes D. Cerebral blood flow associated with creative performance: a comparative study. Neuroimage 2007;38: 519-28.

[96] Rimland B. Infantile Autism: the Syndrome and its implications for a neural theory of behavior. New York: Appleton-Century-Crofts; 1978.

[97] Casanova MF, Switala AE, Trippe J, Fitzgerald M. Comparative minicolumnar morphometry of three distinguished scientists. Autism, The International Journal of Research and Practice 2007;11: 55-569.

[98] Casanova M, Trippe J. Radial cytoarchitecture and patterns of cortical connectivity in autism. In: Happé F, Frith U. (eds.) Autism and talent. Philosophical transactions of The Royal Society 2009; vol. 364 (1522) p1433-1436.

[99] Belmonte et al 2004.

[100] Geschwind N, Miller BL. Molecular approaches to cerebral laterality: development and neurodegeneration. American Journal of Medical Genetics 2001;101: 379-381.

[101] Brugger P, Graves R.E. Right hemispatial inattention and magical ideation. European Archive for Psychiatry Clinical Neuroscience 1997;247: 55-57.

[102] Smalley SL, Loo SK, Yang MH, Cantor RM. Toward Localizing Genes Underlying Cerebral Asymmetry and Mental Health. American Journal of Medical Genetics Part B (Neuropsychiatric Genetics) 2004;135B: 79-84.

[103] Brugger & Graves, 1997.

[104] Weinstein S, Graves RE. Are creativity and schizotypy products of a right hemisphere bias? Brain Cognition 2002;49: 138-151.

[105] Smalley et al 2004.

[106] Smalley SL, Kustanovich V, Minassian S, Stone JL, Ogdie MN. et al. Genetic linkage of attention-deficit/hyperactivity disorder on chromosome 16p13, in a region implicated in autism. American Journal Human Genetics 2002;71: 959-963.

[107] Overby LA III, Harris AE, Leek MR. Perceptual asymmetry in schizophrenia and affective disorder: Implications from a right hemisphere task. Neuropsychologia 1989;27: 861-870.

[108] Weinstein & Graves 2002.

[109] Bigler ED, Mortensen S, Neeley ES, Ozonoff S, Krasny, L, Johnson M, Lu J, Provencal SL, McMahon W, Lainhart, JE. Superior temporal gyrus, language function, and autism. Developmental Neuropsychology 2007;31: 217-38.

[110] Herbert MR, Ziegler DA, Deutsch CK, O'Brien LM, Kennedy DN, Filipek PA, Barkardjiev AI, Hodgson J, Takeoka M, Makris N, Caviness Jr VS. Brain asymmetries in autism and developmental language disorder: a nested whole-brain analysis. Brain 2005;28: 213-226.

[111] Geschwind N, Galaburda AM. Cerebral Lateralization: Biological Mechanisms, Associations, and Pathology. Cambridge: MIT Press; 1987.

[112] Herbert et al 2005.

[113] Treffert D. The idiot savant: a review of the syndrome. American Journal of Psychiatry 2000; 45: 563-572.

[114] Miller BL, Boone K, Cummings LR, Mishkin F. Emergence of artistic talent in frontotemporal dementia. Neurology 1998;51: 978-982.

[115] Sacks O. Musicophilia: tales of music and the brain. New York: Knopf Publishing Group; 2007.

[116] Treffert 2009.

[117] Kapur N. Paradoxical functional facilitation in brain-behaviour research: a critical review. Brain 1996;119 1775-1790.

[118] Hyde K, Zatorre R, GriffithsTD, Lerch JP, Peretz I. Morphometry of the amusic brain: A two-site study. Brain 2006;129:2562-70.

[119] Martindale C, Hines D, Mitchell L, Covello E. EEG alpha asymmetry and creativity. Personality and Individual Differences 1984;5: 77-86.

[120] Smith SD, Dixon MJ, Tays WJ, Bulman-Fleming MB. Anomaly detection in the right hemisphere: The influence of visuospatial factors. Brain Cognition 2004;55: 458-62.

[121] Geschwind DH, Miller BL, DeCarli C, Carmelli D. Heritability of lobar brain volumes in twins supports genetic models of cerebral laterality and handedness. Proceedings of the National Academy of Sciences USA 2002;99: 3176-3181

[122] Herrmann N. The creative brain. Lake Lure, N.C: Applied Creative Services; 1988.

[123] Hardan AY, Muddasani S, Vemulapalli M, Keshavan MS, Minshew NJ. An MRI study of increased cortical thickness in autism. American Journal of Psychiatry 2006;163: 1290-92.

[124] Dissanayake C, Bui QM, Huggins R, Loesch DZ. Growth in stature and head circumference in high-functioning autism and Asperger disorder during the first 3 years of life. Development and Psychopathology 2006;18: 381-93.

[125] Courchesne E, Pierce K. Brain overgrowth in autism during a critical time in development: Implications for frontal pyramidal neuron and interneuron development and connectivity. International Journal of Developmental Neuroscience 2005; 23: 153-70.

[126] Courchesne E. Brain development in autism: Early overgrowth followed by premature arrest of growth. Mental retardation and Developmental Disabilities. Research Reviews 2004;10 106-11.

[127] Mraz KD, Green J, Dumont-Mathieu T, Makin S, Fein D. Correlates of head circumference growth in infants later diagnosed with autism spectrum disorders. Journal of Child Neurology 2007;22: 700-13.

[128] Dissanayake et al 2006.

[129] Mills JL, Hediger ML, Molloy CA, et al. Elevated levels of growth-related hormones in autism and autism spectrum disorder. Clinical Endocrinology 2007;67: 230-37.

[130] Crespi B, Badcock C. Psychosis and autism as diametrical disorders of the social brain. Behavioral and Brain Sciences 2008;31: 284-320.

[131] Turner KC, Frost L, Linsenbardt D, McIlroy JR, Müller RA. Atypically diffuse functional connectivity between caudate nuclei and cerebral cortex. Behavioural and Brain Functions 2006;2 34.

[132] Schumann KC, Hamstra J, Goodlin-Jones BL, Lotspeich LJ, et al. The amygdala is enlarged in children but nor adolescents with autism; the hippocampus is enlarged at all ages. Journal of Neuroscience 2004; 25: 6392-6401.

[133] Egaas B, Courchesne E, Saitoh O. Reduced size of corpus callosum in autism. Archives of Neurology 1995; 52: 794-801.

[134] Belmonte et al 2004.

[135] Just MA, Cherkassky VL, Keller TA. Kana, RK, Minshew N. (Functional and Anatomical Cortical Underconnectivity in autism: Evidence from a fMRI Study of an Executive function task and Corpus Callosum Morphometry. Cerebral Cortex 2007;17: 951-961.

[136] Casanova et al 2007.

[137] Casanova et al 2009.

[138] Smalley et al 2004.

[139] Gardner H. Extraordinary Minds. New York: Basic Books; 1997.

[140] Lykken DT. The mechanism of emergenesis. Genes, Brain & Behavior 2006;5: 306-310.

[141] Howe MA. Genius Explained. Cambridge: Cambridge University Press; 1999.

[142] Happé F, Frith U. The beautiful otherness of the autistic mind. Introduction. appé F, Frith U. (eds.) Autism and talent. Philosophical transactions of The Royal Society 2009; vol. 364 (1522) p.1345-1350.

[143] Fitzgerald 2004.

[144] Fitzgerald 2005.

[145] Fitzgerald 2005.

[146] Happé &Vital 2009.

[147] Goldstein S. Schwebach AJ. A comorbidity of pervasive developmental disorder and Attention Deficit Hyperactivity Disorder: results of a retrospective chart review. Journal of Autism & Developmental Disorders 2004;34 (3): 329-339.

[148] Fitzgerald M. Did Lord Byron have Attention Deficit Hyperactivity Disorder? Journal of Medical Biography 2001;9: 31-33.

[149] Smalley et al 2002.

[150] Smalley et al 2004.

http://dx.doi.org/10.5772/54465

[151] Andreasen NC. Creativity and mental illness: prevalence rates in writers and their first-degree relatives. American Journal of Psychiatry 1987;144: 1288-1292.

[152] Andreasen NC 1987.

[153] Folley et al 2003.

[154] Sternberg RJ, Lubart TI. Defying the crowd: Cultivating creativity in a culture of conformity. New York: Free Press; 1995.

[155] Grandin 1995.

[156] Lyons V, Fitzgerald M. Asperger Syndrome. A Gift or a Curse? New York: Nova Science Publishers; 2005.