Savants: the Keys to Understanding and Unlocking the Full Potential of Human Memory and Cognition

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About the Author:

Dr. Darold A. Treffert is a psychiatrist who specializes in autism spectrum disorders and savant syndrome. Dr. Treffert has been studying savant syndrome for over 40 years. His first book, *Extraordinary People*, was the first work to comprehensively summarize what is known about this fascinating condition, and to introduce the reader to a number of present day prodigious savants. In April 2010, Dr. Treffert published *Islands of Genius: The Bountiful Mind of the Autistic, Acquired and Sudden Savant*. It won gold in the Psychology/Mental Health Category at the 2011 Independent Publisher Book Awards and silver in the Psychology Category at the ForeWord 2011 Book of the Year Awards. Dr. Treffert was also a consultant for the movie Rain Man, a movie based on the true story of the autistic savant Kim Peek. Treffert has written articles in Scientific American and MIND. “Savant Syndrome: An Extraordinary Condition” was originally published on April 12th in the Philosophical Transactions of the Royal Society of London. The article is an overview of everything currently known about savant syndrome including what it is, theories about causes, connections to other mental disorders such as autism, and possibility of awakening similar abilities in normal humans.

Abstract

Savant syndrome is a rare but extraordinary condition in which persons with serious mental disabilities, including autistic disorder, have some “island of genius” that stands in marked, incongruous contrast to overall handicap. In fact, as many as one in 10 autistic persons has such remarkable abilities in varying degrees, although savant syndrome occurs in other developmental disabilities or CNS injury or disease as well. While J. Landon Down included 10 such cases in his original description of this interesting circumstance in 1887, and Kanner included some such cases in his first accounts of early infantile autism in 1943, it was the 1989 movie Rain Man that made “autistic savant” a household term. While there is as yet no overarching theory to explain all instances of savant syndrome, more progress has been made in better understanding this condition in the past 15 years than in the prior 100.

This article summarizes past and present world literature on this topic, describes more recent cases, reviews current research findings, provides intervention strategies to channel such skills, and outlines future directions of inquiry to better explain this extraordinary condition. Recent case reports increasingly implicate left hemisphere dysfunction with right hemisphere compensatory processes as an important causal component in many cases of savant syndrome, including those occurring in persons with autistic disorder. Especially intriguing are reports of newly emerging art, music and other savant-like skills in previously nondisabled persons following CNS injury or disease. These cases of “acquired” savant syndrome raise the possibility of hidden potential, perhaps, within us all, and add to findings that
implicate left hemisphere dysfunction as a causal factor in savant syndrome overall.

Savant skills in autistic persons, rather than being irrelevant and frivolous, can in fact, by “training the talent,” serve as a “conduit toward normalization,” with an increase in language, social, and daily living skills, providing more independence for the savant overall. Examples of such useful intervention and channeling are provided.

New imaging techniques and other novel research approaches, described herein, provide additional tools to better explore the unique window into the brain that this remarkable condition provides with its vast implications for not only better understanding savant syndrome, but perhaps shedding light as well on the hidden within us all. No model of brain function, including memory, will be complete until it can fully incorporate and explain this jarring juxtaposition of severe mental handicap and prodigious mental ability. The journey toward such an explanation is underway.

1. Introduction

Without doubt, the best-known autistic savant is a fictional one, Raymond Babbitt, as portrayed by Dustin Hoffman in the 1988 movie Rain man. However, the original inspiration for the savant portrayed in Rain man was a now 57-year-old male who has memorized over 6000 books and has encyclopedic knowledge of geography, music, literature, history, sports and nine other areas of expertise (Peek & Hanson 2008). He can name all the US area codes and major city zip codes. He has also memorized the maps in the front of telephone books and can tell you precisely how to get from one US city to another, and then how to get around in that city street by street. He also has calendar-calculating abilities and, more recently, rather advanced musical talent has surfaced. Of unique interest is his ability to read extremely rapidly, simultaneously scanning one page with the left eye and the other page with the right eye. Magnetic resonance imaging (MRI) shows the absence of the corpus callosum along with other substantial central nervous system (CNS) damage.

The combination of blindness, mental handicap and musical genius is conspicuously over-represented throughout the reports of savant syndrome from earliest times. Prominent cases include Blind Tom who travelled internationally and became famous in the 1800s, Tredgold's case at the Salpetriere even earlier than that and a number of well-known present-day musical savants. Why that rare triad of musical genius, blindness and mental handicaps should occur so consistently in the already rare condition of savant syndrome deserves very careful study.

Reports of female savants continue to be relatively few. Selfe (1978) described the case of Nadia, which has triggered considerable debate about the possible ‘trade-off’ of special skills for language and social skills acquisition. Viscott (1969) documented in detail, including psychodynamic formulations, a female musical savant whom he followed for many years. Treffert (2006a) described a blind, autistic musical savant who, along with her musical ability, demonstrated very precise spatial location abilities and precise time-keeping skills without access to a clock face or other time instruments.

Detailed reports of these and many other savants dating from Down's original description of the disorder are contained in Extraordinary people: understanding savant syndrome (Treffert 2006a).
Moreover, information about many of them, including some video clips, can be accessed on the savant syndrome website at www.savantsyndrome.com maintained by the Wisconsin Medical Society Foundation.

2. Where we have been

Savant syndrome, with its ‘islands of genius’, has a long history. The first account of savant syndrome in a scientific paper appeared in the German psychology journal, Gnothi Sauton, in 1783, describing the case of Jedediah Buxton, a lightning calculator with extraordinary memory (Mortiz 1783). Rush (1789), the father of American psychiatry, also provided one of the earliest reports when he described the lightning calculating ability of Thomas Fuller ‘who could comprehend scarcely anything, either theoretical or practical, more complex than counting’. However, when Fuller was asked how many seconds a man had lived who was 70 years, 17 days and 12 hours old, he gave the correct answer of 2210500800 in 90s, even correcting for the 17 leap years included (Scripture 1891).

However, the first specific description of savant syndrome took place in London in 1887 when Dr J. Langdon Down gave that year's prestigious Lettsomian Lecture at the invitation of the Medical Society of London. In that lecture, he reflected on his 30 years as a physician at the Earlswood Hospital and described ‘an interesting class of cases for which the term ‘idiot savants’ has been given, and of which a considerable number have come under my observation’. He then presented 10 cases of persons with ‘special faculties’ that read exactly similar to cases now 121 years later. One of his patients had memorized The rise and fall of the Roman Empire verbatim and could recite it backwards or forwards. Other children drew with remarkable skill but ‘had a comparative blank in all the other faculties of mind’. Still other children showed music ability, arithmetical genius or precise timekeeping skill, all of which, taken together, comprised a clinical picture of savant syndrome—special skills+phenomenal memory—which unfailingly reoccurs in case reports to this day.

In 1887, ‘idiot’ was an accepted classification for persons with an IQ below 25, and ‘savant’, or ‘knowledgeable person’, was derived from the French word savoir meaning ‘to know’. Down joined those words together and coined the term idiot savant by which the condition was generally known over the next century. While descriptive, the term was actually a misnomer since almost all cases occur in persons with an IQ higher than 40. In the interest of accuracy and dignity, savant syndrome now has been substituted and is widely used. Savant syndrome is preferable to ‘autistic savant’ since only approximately 50 per cent of persons with savant syndrome have autistic spectrum disorder and the other 50 per cent have some other forms of CNS injury or disease.

Tredgold (1914), also from the Earlswood Hospital, wrote a very comprehensive account of savant syndrome in a chapter in his well-known textbook, Mental deficiency. This classic chapter, which was carried for many years into subsequent editions, described over 20 additional cases from a variety of clinicians. Hill (1978), provided a review of the literature between 1890 and 1978, including 60 reports involving over 100 savants. That same year, Rimland provided a summary of his data on ‘special abilities’ in 531 cases from a survey population of 5400 children with autism. Treffert (1988) provided an updated review, which contained more detail on all of those earlier cases and suggested
that the name of the condition be changed to savant syndrome. In 1989, Extraordinary people was first published by Treffert, summarizing a century of cases, observations and research findings since Down's 1887 description of the disorder. In her book, Bright splinters of the mind, Hermelin (2001) summarized her findings based on 20 years of research by her and her co-workers. A comprehensive review article by Heaton & Wallace (2004) also provides an extensive bibliography on research to that date.

(a) Did Dr Down describe autism?

While Down is best known for having described Down's syndrome (trisomy 21) and savant syndrome in his 1887 lecture, he made an additional very astute observation about what he called ‘developmental retardation’. Today, that condition is known as autistic disorder (Treffert 2006b). Reflecting on his 30 years of experience, he divided mental retardation into ‘congenital’ and ‘accidental’ categories. However, he mentioned, there was a third kind of mental retardation that occurred in children who did not have the usual ‘physical aspects’ of retardation. Some of these children had developed normally and then suddenly regressed and ‘lost wonted brightness’ and ‘lost speech’. There was the suspension of ‘normal intellectual growth’. These children lived ‘in a world of their own’, spoke ‘in the third person’, had ‘rhythmical and automatic movements’ and ‘lessened responsiveness to all endearments of friends’.

Down called this ‘developmental retardation’ and described what are, without doubt, cases of both early-onset and late-onset (regressive) autism. That he should choose the term ‘developmental’ for this form of disorder is interesting indeed, because it was fully 93 years later that the term ‘developmental disorders’ was included, for the first time, in the DSM III (DSM-III, 2009), for the category in which autistic disorder was included. The fact that regressive or late-onset autism occurred, and was described so accurately by Down, more than a century ago is an important perspective to bear in mind in present-day discussions about the autism ‘epidemic’ and causes of regressive autism.

Of course, it was Kanner (1944) who described what he called ‘early infantile autism’. Many of the same behaviours and traits Down commented on in his developmental retardation group of patients were similarly noted by Kanner in his description of his 10 original cases. Six of those individuals had special musical abilities and Kanner was struck as well by the overall heightened memory capacity of all 10 persons in that original group.

3. What we do know

After several centuries of reports and observations, we know that:

(a) The condition is rare but one in 10 autistic persons show some savant skills

In Rimland's (1978) survey of 5400 children with autism, 531 were reported by parents to have special abilities and a 10 per cent incidence of savant syndrome has become the generally accepted figure in autistic disorder. Hermelin (2001), however, estimated that figure to be as low as ‘one or two in 200’. But the presence of savant syndrome is not limited to autism. In a survey of an institutionalized population with a diagnosis of mental retardation, the incidence of savant skills was 1:2000 (0.06%; Hill 1977). A more recent study surveyed 583 facilities, and found a prevalence rate of 1.4 per 1000, or approximately double the Hill estimate.
Whatever the exact figures, mental retardation and other forms of developmental disability are more common than autistic disorder, so a reasonable estimate might be that approximately 50 per cent of persons with savant syndrome have autistic disorder and the other 50 per cent have other forms of developmental disability, mental retardation or other CNS injury or disease. Thus, not all autistic persons have savant syndrome and not all persons with savant syndrome have autistic disorder.

(b) Males outnumber females in autism and savant syndrome

Males outnumber females by an approximate 6:1 ratio in savant syndrome compared with an approximate 4:1 ratio in autistic disorder. In explaining that finding, Geschwind & Galaburda (1987) in their work on cerebral lateralization pointed out that the left hemisphere normally completes its development later than the right hemisphere and is thus subjected to prenatal influences, some of which can be detrimental, for a longer period of time. In the male foetus particularly, circulating testosterone, which can reach very high levels, can slow growth and impair neuronal function in the more vulnerably exposed left hemisphere, with actual enlargement and shift of dominance favouring skills associated with the right hemisphere. A ‘pathology of superiority’ was postulated, with compensatory growth in the right brain as a result of impaired development or actual injury to the left brain.

This finding may account as well for the high male:female ratio in other disorders, including autism itself since left hemisphere dysfunction is often seen in autism (Treffert 2005, 2006a). Other conditions, such as dyslexia, delayed speech and stuttering, also have a male predominance in incidence, which may be a manifestation of the same left hemisphere growth interference in the prenatal period described above.

(c) Savant skills typically occur in an intriguingly narrow range of special abilities

Considering all the abilities in the human repertoire, it is interesting that savant skills generally narrow to five general categories: music, usually performance, most often piano, with perfect pitch, although composing in the absence of performing has been reported as has been playing multiple instruments (as many as 22); art, usually drawing, painting or sculpting; calendar calculating (curiously an obscure skill in most persons); mathematics, including lightning calculating or the ability to compute prime numbers, for example, in the absence of other simple arithmetic abilities; and mechanical or spatial skills, including the capacity to measure distances precisely without benefit of instruments, the ability to construct complex models or structures with painstaking accuracy or the mastery of map making and direction finding.

Other skills have been reported less often, including: prodigious language (poly-glott) facility; unusual sensory discrimination in smell, touch or vision including synaesthesia; perfect appreciation of passing time without benefit of a clock; and outstanding knowledge in specific fields such as neurophysiology, statistics or navigation. In Rimland's (1978) sample of 543
children with special skills, musical ability was the most frequently reported skill followed by memory, art, pseudo-verbal abilities, mathematics, maps and directions, coordination, calendar calculating and extrasensory perception. Hyperlexia, which is distinguished by precocity rather than age-independent level of skill, has also been frequently reported in autism (Grigorenko et al. 2002).

Generally, a single special skill exists but, in some instances, several skills exist simultaneously. Rimland & Fein (1988) noted that the incidence of multiple skills appeared to be higher in savants with autism than in savants with other developmental disabilities. Whatever the special skill, it is always associated with prodigious memory. Some observers list memory as a separate special skill; however, prodigious memory is an ability all savants possess cutting across all of the skill areas as a shared, integral part of the syndrome itself. Several investigators have shown that memory alone cannot fully account for savant abilities, particularly calendar calculating and musical skills (Nettlebeck & Young 1999; Hermelin 2001). Formal testing for eidetic imagery shows that phenomenon to be present in some, but certainly not all, savants and when present it may exist more as a marker of brain damage than being central to savant abilities (Bender et al. 1968; Giray & Barclay 1977).

(d) There is a spectrum of savant skills

The most common are splinter skills, which include obsessive preoccupation with, and memorization of, music and sports trivia, license plate numbers, maps, historical facts or obscure items such as vacuum cleaner motor sounds, for example. Talented savants are those cognitively impaired persons in whom the musical, artistic or other special abilities are more prominent and highly honed, usually within an area of single expertise and are very conspicuous when viewed in contrast to overall disability. Prodigious savant is a term reserved for those extraordinarily rare individuals for whom the special skill is so outstanding that it would be spectacular even if it were to occur in a non-impaired person. There are, from my experience, probably fewer than 100 known prodigious savants living worldwide at the present time who would meet that very high threshold of savant ability.

(e) The special skills are always accompanied by prodigious memory

Whatever the special abilities, a remarkable memory of a unique and uniform type weds the condition together. Terms such as automatic, mechanical, concrete and habit-like have been applied to this extraordinary memory. Down (1887) used the term ‘verbal adhesion’; Critchley (1979) used the term ‘exultation of memory’ or ‘memory without reckoning’; Tredgold (1914) used the term ‘automatic’; and Barr (1898) characterized his patient with prodigious memory as ‘an exaggerated form of habit’. Such unconscious memory suggests what Mishkin et al. (1984) referred to as non-conscious ‘habit’ formation rather than a ‘semantic’ memory system. They proposed two different neural circuits for these two different types of memory: a higher level corticolimbic circuit for semantic memory and a lower level cortico-striatal circuit for the more
primitive habit memory, which is sometimes referred to as procedural or implicit memory. Savant memory is characteristically very deep, but exceedingly narrow, within the confines of the accompanying special skill.

(f) Savant syndrome can be congenital or it can be acquired

Most often savant skills emerge in childhood, superimposed on some underlying developmental disability present at birth. However, ‘acquired’ savant skills can also appear, when none were previously present, in neurotypical individuals following brain injury or disease later in infancy, childhood or adult life (Lythgoe et al. 2005; Treffert 2006a). Recent reports of savant-type abilities emerging in previously healthy elderly persons with fronto-temporal dementia have been particularly intriguing (Miller et al. 1998, 2000; Hou et al. 2000). The prospect of dormant potential triggered, or released, by CNS injury existing within each person has far-reaching implications, as discussed elsewhere in this volume.

An important question is whether special skills are found in first-degree relatives of savants. Two studies, one with 25 savants and another with 51 subjects, showed relatives with special skills in some but certainly not all cases (Duckett 1976; Young 1995). Another study of 23 relatives of carefully studied savants found only one family member with special skills (LaFontaine 1974).

Young (1995) travelled to a number of countries and met with 51 savants and their families, completing the largest study performed on savants to date using uniform history taking and standardized psychological testing. Forty-one savants carried a diagnosis of autism and the remainder some other type of intellectual disability: 12 were rated as prodigious savants; 20 were rated as talented; and the remaining 19 had splinter skills. The savants in this series of cases had the following elements in common: neurological impairment with idiosyncratic and divergent intellectual ability; language and intellectual impairments consistent with autism; intense interest and preoccupation with particular areas of ability; rule-based, rigid and highly structured skills lacking critical aspects of creativity and cognitive flexibility; preserved neurological capacity to process information relating to the particular skills; a well-developed declarative memory; a family history of similar skills in some, but not all, cases but even in the absence of a history of a specific skill, there was a familial predisposition towards high achievement; and a climate of support, encouragement and reinforcement from families, case workers, teachers, caretakers and others.

(g) Savant skills do not fade or disappear; rather a pattern of replication to improvisation to creation is often seen

The case of Nadia, who lost her special art skills when exposed to traditional schooling, raised the prospect of a ‘dreaded trade-off’ of savant skills for acquisition of better language, communication and daily living skills (Selle 1978). But experience has shown that such loss of special skills is the exception rather than the rule in savant syndrome. Instead, with continued
use, the special abilities either persist at the same level or actually increase.

Now that I have had an opportunity to follow the unfolding of savant abilities in some individuals for nearly 30 years, I have seen a pattern of progression of savant abilities in a number of prodigious savants particularly that ends in the capacity to be creative. In the light of these observations, I would revise my original comments in my book Extraordinary people that savants certainly demonstrated remarkable talent, and stunning replication abilities, but were not very creative. I was wrong.

The pattern I have observed begins with spectacular, literal replication of things seen or heard. Leslie Lemke, for example, played back Tchaikovsky's first piano concerto flawlessly at age 14, having heard it for the first time as a theme song to a television movie. From there Leslie moved, over time, from literal replication (which he can still do) to improvisation, seemingly having become bored with just reproducing what he has heard. In recent years, Leslie has moved now to creation of entirely new songs that he composes, plays and sings. This pattern of replication to improvisation to creation has been demonstrated in other musical savants. A well-known Japanese musical savant's ability as a composer demonstrates decisively that savants can be creative; his 40 original pieces on two internationally popular CDs forcefully document that ability (Cameron 1998).

That same transition can be seen in artistic savants. For example, Stephen Wiltshire can certainly replicate in stunning fashion what he sees as demonstrated in a recent documentary film clip, when, after a 45min helicopter ride over Rome, he completed, in a three-day drawing marathon, an impeccably accurate drawing, on a five and half yard canvas. It captures with precision the many square miles he has seen street by street, building by building and column by column. A blueprint of the coliseum, superimposed on his drawing, shows an astonishing accurate replication. That clip can be seen at www.savantsyndrome.com. However, Stephen can also improvise in his drawings, and he can also create scenes of his choosing. He has several art books published, and now has his own art gallery in London, which displays his various drawing styles (Wiltshire 1987, 1991).

There are other examples of this same replication to improvisation to creation pattern that space prohibits describing here. However, they are documented in Extraordinary people and on the savant syndrome website in detail.

(h) No single theory can explain all savants

Since Down's first description of savant syndrome, numerous theories have been put forth to explain this astonishing juxtaposition of ability and disability in the same person. Space precludes outlining those here but I do discuss them in detail in Extraordinary people. In the ‘How do they do it?’ chapter in that book, I outline in detail as well my speculation, based on observation, imaging and neuropsychological studies of a number of savants, that one mechanism in some savants, whether congenital or acquired, is left brain dysfunction with right brain compensation, a form of ‘paradoxical functional facilitation’ as described by Kapur
(1996). Brink (1980) raised that possibility with a case in which left brain injury in a child gave rise to some mechanical and other savant skills. Miller's recent work with persons with fronto-temporal dementia (FTD) in whom savant skills surfaced, sometimes at a prodigious level, adds impetus to that speculation (Miller et al. 1998, 2000). Those studies led him to conclude that ‘loss of function in the left anterior lobe may lead to facilitation of artistic or musical skills’. Hou et al. (2000) stated it this way: ‘The anatomic substrate for the savant syndrome may involve loss of function in the left temporal lobe with enhanced function of the posterior neocortex’.

Other current theories, including genetic, cognitive and neural, will be explored in other contributions to this volume.

4. ‘Training the talent’: successful educational approaches

Aetiologic considerations aside, what is the best approach to the savant and his or her special skills? Phillips framed the controversy in 1930 when he stated: ‘The problem of treatment comes next…is it better to eliminate the defects or train the talent?’ Experience has provided a clear answer—‘train the talent’! And as one does so, some of the ‘defect’ subsides. The special talent, in fact, becomes a conduit towards normalization, using the unique savant skills to achieve better socialization, language acquisition and independence, all without the trade-off or loss of special abilities for those valuable gains in other areas of functioning. The special skills can be used as a way of engaging attention of the savant, and rather than seeing the special abilities as frivolous, they can be used as a form of expression with the goal of channelling those abilities more usefully.

Clark (2001) developed a savant skill curriculum using a combination of successful strategies currently employed in the education of gifted children (enrichment, acceleration and mentorship) and autism education (visual supports and social stories) in an attempt to channel and apply, usefully, the often non-functional obsessive savant and splinter skills of a group of students with autism. This special curriculum proved highly successful in the functional application of savant skills and an overall reduction in the level of autistic behaviours in many subjects. Improvements in behaviour, social skills and academic self-efficacy were reported, along with gain in the communication skills of some subjects.

Donnelly & Altman (1994) noted that increasing numbers of ‘gifted students with autism’ are now being included in gifted and talented classrooms with non-disabled gifted peers. Accompanying elements are an adult mentor in the field of their talent, individual counselling and small-group social skills training.

Some specialized schools are emerging as well. For example, Soundscape Centre in Surrey, England began operating in 2003 as the only specialized educational facility in the world uniquely dedicated to the needs and potential of persons with sight loss and special musical abilities, including musical savants. Orion Academy (www.orionacademy.org) in Moraga, California, USA specializes in providing a positive educational experience for high school students with Asperger's syndrome. Hope University (www.hopeu.com) in Anaheim, California is a fine arts facility for adults with developmental disabilities. Its mission is to ‘train the talents and diminish the disability’ through the use of fine arts
therapy including visual arts, music, dance, drama and storytelling.

Dr Temple Grandin is well known as an international authority in her field of animal science. She is also well known for her books including Thinking in pictures (1995) and Translating with animals (2005). She is also autistic. Another recent book, Developing talents: careers for individuals with Asperger syndrome and high-functioning autism (Grandin & Duffy 2004), is an excellent, practical resource for discovering, nurturing and ‘training the talent’ so that many persons on the autistic spectrum can enjoy the important experience of work and ‘the satisfaction of contributing to their families and their communities, of being independent and economically self-sufficient’. This book outlines methods of helping children ‘develop their natural talents’ using ‘drawing, writing, building models, programming computers’ and similar skills to help build a ‘portfolio’ of skills that can help in the search for a meaningful work experience.

The book helps persons on the autistic spectrum, and their family members, teachers, counsellors and others to better understand and develop the career planning process for these special persons with special skills.

5. Future directions

No model of brain function, including memory, will be complete until it can account for, and fully incorporate, the rare but spectacular condition of savant syndrome. In the past decade, particularly, much progress has been made towards explaining this jarring juxtaposition of ability and disability, but many unanswered questions remain. However, interest in this fascinating condition is accelerating, especially since the discovery of savant-type skills in previously unimpaired older persons with FTD and other acquired savant instances. This finding has far-reaching implications regarding buried potential in some or, perhaps, all of us.

Advanced technologies will help in those investigations. Computed tomography (CT) and MRI provide stunningly high-resolution images of all the brain architecture, surface and deep, permitting detailed inspection of brain structure. However, studies of brain function, such as positron emission tomography (PET), single photon emission CT (SPECT) or functional MRI, are much more informative regarding savant syndrome, and, indeed, autism itself, since these newer techniques provide information about the brain at work, rather than simply viewing brain architecture. An even more recent imaging technique is diffusion tensor imaging, based on measuring water flow within neurons, which provides graphic images of brain connectivity between the brain hemispheres, within the brain hemispheres and between upper cortical and lower brain stem structures. A related technique, diffusion tensor tracking, provides a direct visual view of the actual fibre tracks, or wiring, of the brain in great detail.

One of the drawbacks to savant functional imaging research, especially art and music performance skills, has been the necessary immobilization of the subject when doing the imaging. Near-infrared spectroscopy, which measures haemoglobin, uses an infrared cap which the patient can wear while ‘at work’ performing music or painting or drawing, for example. Also there have been many advances in electroencephalographic techniques, including magnetoencephalography, which provides a
great deal of additional information beyond the usual electroencephalographic findings.

Detailed, standardized neuropsychological test results can then be correlated with the imaging findings in savants in sufficiently large samples to move away from what have been so many single subject, anecdotal reports. Control groups of non-impaired persons can be assembled to compare and contrast findings in both groups. Beyond that, since the interface between genius, prodigies and savants is an important, and in some ways a very narrow one, those persons should be included also in these multidisciplinary, multimodality, compare and contrast studies. Such studies can shed light on the debate regarding general intelligence versus separate intelligences. Some researchers suggest that savants provide a unique window into the creative process itself. From studies already completed, important information has already emerged regarding brain function, brain plasticity, CNS compensation, recruitment and repair.

Savant syndrome, both in the congenital and acquired types, provides compelling evidence of remarkable brain plasticity. Indeed, brain plasticity will be a central aspect of all neuroscience research in the decades ahead. Until fairly recently, there has been what Dodge (2007), in his book The brain that changes itself, calls ‘neurologic nihilism’. This was a generally pessimistic view of the ability of neuronal tissue to regenerate and rewire itself in the face of injury or disease. The concept of one brain area being ‘recruited’ to take over the function of some other damaged area, paradoxical functional facilitation (Kapur 1996), is central to explaining savant syndrome. Some argue that the ‘recruitment’ of abilities is actually a ‘release’ phenomenon of already existing, but dormant, abilities as opposed to the compensatory development of new skills. In the case of right brain versus left brain capacity, some have referred to that substitution as a release ‘from the tyranny’ of the left, or dominant, hemisphere.

But there is more to savant syndrome than genes, circuitry and the brain's marvellous intricacy. As important as those matters are in terms of scientific interest, there is also much we can learn from savant syndrome from the human interest perspective provided by these remarkable people, and the equally remarkable and dedicated families, caretakers, teachers and therapists who surround them. For human potential consists of more than neurons and synapses. It also comprises, and is propelled along by, the vital forces of encouragement and reinforcement that flow from the unconditional love, belief, support and determination of those families and friends who not only care for the savant, but care about him or her as well.

At a 1964 meeting of the American Psychiatric Association, a discussant concluded, with respect to the ‘calculating twins’, that the importance of the savant ‘lies in our inability to explain him; he stands as a landmark of our own ignorance and the phenomenon of the idiot savant exists as a challenge to our capabilities’ (Horwitz et al. 1965). But savant syndrome is less now a ‘landmark to our ignorance’ than 44 years ago. More progress has been made in the past 15 years in better understanding and explaining savant syndrome than in the previous 100 years. Also, that important inquiry continues, with the prospect of propelling us along further than we have ever been in unravelling the mystery of these extraordinary people and their remarkable abilities. Moreover, in that process, we can also learn more about ourselves, explore the ‘challenge to our capabilities’ and uncover the hidden
potential—the little Rain man—that resides, perhaps, within us all.

Questions:
1. What is the tone of this article?
   Dr. Treffert writes mostly objectively and didactically yet there are occasional moments in the article where his appreciation and admiration for savants shows through such as the final paragraphs. He wants to present the reader with the facts necessary to come the same conclusion he has reached.

2. Who is Dr. Treffert is trying to reach with this piece?
   Some people feel uncomfortable or just perplexed when dealing with savants who likely have a mental disorder such as autism. Dr. Treffert wants them to gain an understanding of savants and appreciate that they can offer something incredibly valuable to the field of science. Savants are not only truly incredible people but could also be the keys to unlocking these seemingly astronomical abilities in normal humans.

3. What does Dr. Treffert mean by “island of genius”?
   While savants do have remarkable cognitive abilities, those abilities are most times coupled with other handicaps that come with a mental disorder. The most common one coupled with savant syndrome is autism which can result in a lack of social skills, reasoning ability, or mood control.

4. Why does Dr. Treffert call the term “idiot savant” regrettable?
   Savants are far from idiots, they are “islands of genius” with abilities far beyond normal human capabilities.
Savant Syndrome
David Hiles

About the Author:
David Hiles is a psychology professor at De Montfort University in Leicester, England. The university has one of the largest numbers of Teacher Fellows in the United Kingdom and was awarded Centre of Excellence status. Hiles has a BSc (Hons) Psychology from the University of Hull and MSc and PhD in Psychology from McGill University with an especial interest in savant syndrome. Hiles believes there are two necessary components of the savant syndrome: (i) a remarkable ability to memorize, to record detail, or repeat an operation endlessly and efficiently, and (ii) a means of giving expression to this ability. In this piece, Hiles describes savant syndrome, its connection with autism, the different types of savant skills and savant levels, and a specific case of an artistic savant called Tim.

# What is Savant Syndrome?

Savants are people who despite serious mental or physical disability have quite remarkable, and sometimes spectacular, talents. This is an exceedingly rare phenomena, although there are several well documented cases (see Sacks, 1986; 1995; Treffert, 1989), and recently the Academy Award winning movie Rain Man has led to the term savant being much more widely known. Savant syndrome is perhaps one of the most fascinating phenomena in the study of human differences and cognitive psychology. It is often claimed that, because of the extraordinary abilities involved, we will never truly understand human memory and cognition until we understand the savant.

Savant syndrome was first properly recognised by Dr. J. Langdon Down, (n.b. he also originated the term Down’s syndrome). In 1887, he coined the term "idiot savant" - meaning low intelligence, and from the French, savoir, knowing or wise, to describe someone who had "extraordinary memory but with a great defect in reasoning power." This term is now little used because of its inappropriate connotations, and the term savant syndrome has now been more or less adopted. Another term, autistic savant, is also widely used, but this can be somewhat misleading. Although there is a strong association with autism, it is certainly not the case that all savants are autistic. It is estimated that about 50% of the cases of savant syndrome are from the autistic population, and the other 50% from the population of developmental disabilities and CNS injuries. The estimated incidence of savant abilities in the autistic population is about 10%, whereas the incidence in the learning disability population (which is very much larger) is probably less than 1%. Nevertheless, in order to understand savant syndrome, it is helpful to know something about autism, also it is important to realize that there is some confusion over these estimates of the incidence of the syndrome which stems from the different ways in which it is defined and described.
#What is Autism?

Autism is a moderately rare condition resulting from a complex developmental disability that typically appears during the first three years of life. It is a neurological disorder that affects the functioning of the developing brain, resulting in sometimes profound communicative, social and cognitive deficits. Autism is estimated to occur in as many as 1 in 500 individuals, and is four times more prevalent in boys than girls and does not seem to be associated with any demographic features, such as economic, class, racial, ethnic, etc. Autistic traits are also sometimes observed in connection with other developmental disabilities, and CNS injuries.

The term autistic was first used by Eugen Bleuler in 1908, but the condition of autism was first named and described by the psychiatrist, Leo Kanner, in a landmark paper published in 1943. It is a condition in which children and adults typically have a lowered level of intelligence, together with difficulties in verbal and non-verbal communication, in the skills of social interaction, and in play activities. The disorder makes it hard for them to relate to the outside world, and there is a marked tendency to withdraw from human interactions and become preoccupied with attachment to objects. There is a failure in human intersubjectivity, characterized by difficulties in joint action, turn taking, and shared activities. Aggressive and/or self-injurious behaviour may well be present. Often there will be continuous repetition of body movements (hand flapping, rocking), a rigidity of actions, resistance to changes in routine, and a "desire" for sameness. Independently of Kanner, in 1944 Hans Asperger, an Austrian physician, described a very similar condition, although there were some subtle differences. In 1981, Lorna Wing adopted the term Asperger’s syndrome in referring to a group of people who did not fit the strict criteria for autism, and were relatively high functioning (see Happé, 1994 for a fuller account).

It is probably best to think of autism as a spectrum disorder. For example, DSM-IV includes autism, grouped together with several related disorders, under the broad heading "Pervasive Developmental Disorder (PDD)." This is a general category of disorders which is characterized by severe and pervasive impairment in several areas of development. There are no medical criteria for diagnosing autism, a specific diagnosis is made when a specified number of characteristics are noted as present, based on the presence of specific behaviours indicated by observation and through parent consultation. Individuals who fall under the PDD category in DSM-IV exhibit commonalities in communication and social deficits, but may differ in terms of severity. Defining autism as a spectrum disorder, recognizes that the symptoms and characteristics of autism can present themselves in a wide variety of combinations, which may also range from mild to severe. Clearly, there is no standard "type" or "typical" person with autism, and the terminology in use includes: autistic traits, autistic tendencies, autism spectrum disorder, high-functioning or low-functioning autism. However, this lecture is not concerned directly with autism, its definition or diagnosis.
Characteristics of Savant Syndrome

Savant syndrome is exceedingly rare, but a remarkable condition in which persons with autism, or other serious mental handicaps, or major mental illness, have astonishing islands of ability or brilliance that stand out in stark contrast to their overall disability. The condition can be congenital or be acquired by an otherwise normal individual following CNS injury or disease. It occurs in males more frequently than in females in an approximate ratio of 6 to 1. The skills can appear suddenly, without explanation, and have been reported as sometimes disappearing just as suddenly. It is useful to put these special skills into the following three categories: Splinter Skills where the individual possesses specific skills that stand in contrast to their overall level of functioning, Talented Savants where the individual displays a high level of ability that is in contrast to their disability, and Prodigious Savants which involves a much rarer form of the condition, where the ability or brilliance is not only spectacular in contrast to the disability, but would be spectacular even if viewed in a non-disabled person. It is very likely that many savants do go unnoticed, and depending upon whether the three categories above are recognized, estimates of the incidence of savant syndrome can vary widely. In the case of prodigious savants it has been estimated that there may be fewer than 100 cases reported in the world literature in the past 100 years.

Categories of Savant Skill

Savant skills occur within a narrow but fairly constant range of human mental functions. If they have anything in common it is that they all more or less involve considerable feats of memory. In some cases a specific skill might exist, while in others there may be several skills that co-exist simultaneously. An important observation is that the skills tend to be right hemisphere oriented: i.e. non-symbolic, artistic, concrete, directly perceived. Table 1 describes some of the striking abilities that have been found in savants.

Table 1: Savant Skills
(n.b. the focus here is on examples of prodigious savants)

Memorization - superior memory is a common feature of savant syndrome, but it also can be a special skill in its own right. There are cases of savants who have memorized population statistics, telephone books, bus schedules, and in one remarkable case the 9 volume edition of Grove’s Dictionary of Music and Musicians (The Walking Grove, Sacks, 1986).

Lightning calculation - this is exhibited in the instantaneous calculation of multiplications, square roots,
etc, the determination of prime numbers, or subitizing (The Twins, Sacks, 1986).

Calendar calculating - often involving the ability to identify the day of the week upon which a particular date falls, in one case any time in the last, or next, forty thousand years!! (The Twins, Sacks, 1986).

Musical ability - this is a relatively common savant skill, the co-occurrence of musical genius, blindness and learning disability is a striking feature here. Savants will have perfect pitch, and can play a complete piece of music after hearing it only once (see Hermelin, 2001).

Artistic ability - not as common as musical abilities, but there are savants with exceptional painting, sculpture and especially drawing skills. e.g. Nadia (Selfe, 1977) and Stephen Wiltshire (1987; 1991; see also Sacks, 1995; Hermelin, 2001). See also The Autistic Artist in Sacks (1986).

Language ability - this is fairly rare, but there is one well documented case of a savant with CNS damage since birth who could read write and translate 15 to 20 languages (Smith & Tsimpli, 1995; Hermelin, 2001). Hermelin also includes a case of a savant poet.

#Theories of Savant Syndrome

The reason why some autistic and disabled individuals have savant abilities is not understood, however, the strong link with autism does offer a good starting point. There have been many theories, but it is clear that no one theory is sufficient. Theories include: Biological-Developmental - such as genetic, neurochemical, left hemisphere dysfunction, frontal and temporal lobe damage, and the DSM IV diagnostic category is Pervasive Developmental Disorder (PDD); Cognitive - such as deficits in executive function and abstract thinking; weak coherence theory; highly developed procedural memory and eidetic imagery (Happé, 1994; Schopler & Mesibov, 1995). Other theories include a deficit in theory of mind (Frith, 1989), compensation for sensory disabilities (especially blindness) and social isolation, and the modularity of mind hypothesis which proposes that particularly when executive cognitive functions are disrupted the mind exhibits a striking modular organization (see Smith & Tsimpli, 1995). However, any theory would need to explain the link with autism, the islands of exceptional ability, the bias towards male savants, and recent research that includes a finding of the emergence of savant abilities in fronto-temporal dementia patients, and the suggestion of a neurotoxic effect of circulating testosterone on the left hemisphere in the male fetus possibly related to autism.

#Some Management Issues

There are two necessary components of the savant syndrome: (i) a remarkable ability to memorize, to
record detail, or repeat an operation endlessly and efficiently, and (ii) a means of giving expression to this ability. The importance of (ii) should not be underestimated. Not only are savants noticed by this expression of their special abilities, but also savants like doing something, and doing it again, again and again. No one has any idea how many savants go unnoticed. In the case of prodigious savants it is possible that early recognition and careful encouragement are important contributory factors to how the talent develops. It has been proposed that helping the savant to achieve a higher level of general functioning may result in a loss of the special savant skills. However, there is little evidence for this, and it may well be that "training the talent" could be a valuable approach towards improving socialization, communication and self-esteem.

#A illustrative case example: Tim, age 40+

Tim has profound sensory and communicative disabilities (his identity has been concealed). He lives in a residential home with day care facilities for adults with learning difficulties, and has been in residential or institutional care since the age of 15. He has no hearing and consequently no speech. He has moderate physical difficulties and sometimes he requires a wheelchair. Tim has probably been disabled since very early childhood, and it is believed that he has been diagnosed as having "autistic traits." But, as far as it is known, his medical records have been destroyed. He has a previous history of challenging behaviour and mood swings, which has in the past been controlled with powerful anti-psychotic drugs. These have been greatly reduced over the 5 years that he has been living at his current residential home, during which time there have been striking changes in his behaviour, including a particularly marked reduction in his challenging behaviour. The most likely reason for this is due mainly to communication barriers being greatly decreased. Despite Tim’s profound disabilities, he is relatively outgoing and is not withdrawn, and he shows a remarkable intelligence (although this would be very difficult to measure formally). He is strong willed, and will only do things that he wants to do. He is helpful, he values affection, and he is considerate to other residents, especially in being tolerant of younger residents. Tim has probably received very little education, he cannot read or write (although he can recognize his name and a few words, and copy any shape that he wishes), but he has been taught a system of alternative communication called Makaton. This is a visual and signing process, usually used alongside speech, which is widely used in the UK by people with learning disabilities. The Makaton Vocabulary was designed in 1972 by Margaret Walker, a UK Speech and language Therapist. She developed Makaton in response to the needs of deaf adults with severe learning disabilities, particularly who were residents in an institution, because other sign communication systems were not very satisfactory. Without Makaton, Tim would only be able to make himself understood with a few crude gestures, and his life could and would be very confusing and frustrating. Tim uses Makaton to initiate conversations, to ask questions, and clarify any situation.
Table 2: Some observations of Tim
Tim draws from memory, and from life
He draws with accurate perspective
He draws with attention to detail
He can draw a good likeness, and can draw a self-portrait
He can draw a "building plan" with a ruler
He finds "hair" very difficult
Tim’s drawing involves deliberate use of lines - "as if tracing an image"
He has a high level of concentration
He is reflective, pausing to think
He chooses his pencils, colours carefully (he knows which pencil/crayon he needs, which box it is in, and he will make a very special effort to match "eye colour")
When drawing from life he takes brief infrequent glimpses
Tim draws what he wants to draw
He likes to draw batteries, light bulbs and lifts
In the past, he did not share his drawings with others, he folded them up very small and put them in his pocket, but kept them all in his room
He has developed his own narrative style of drawing
In addition, he has excellent assembly skills (e.g. IKEA furniture)
His rigidity has relaxed with improved communication

When placed within the context of all these disabilities, Tim possesses extraordinary abilities which primarily are illustrated by his drawing and his photographic memory. As far as it is known, these extraordinary abilities have gone unnoticed, or unrecognized, for most of his life. It was my wife, Elaine, who was the first to recognize Tim’s special abilities. It seems very clear that Tim falls into the category of a savant. What is particularly interesting is that very few cases of savants who are profoundly deaf have ever been documented (the one exception seems to be the case of James Henry Pullen, see Treffert, 1989). I will demonstrate what I am talking about by showing you a selection of his drawings. I will point out a number of features that show how his abilities fit well with those usually attributed to savant syndrome (see Table 2). His drawings are deceptively simple, and it is easy to underestimate the level of his achievements. I will draw especially upon the work of David Hockney (2001) who has recently uncovered some of the techniques used by the old masters in their paintings. Tim has very little difficulty drawing images in accurate perspective that the old masters could only do with sophisticated technical aids. What most people, including skilled artists, would find very difficult to do "by eye", Tim can do with little effort, from memory, sometimes months later, and without any formal instruction or training.
# Summary
At this time, Tim is clearly a talented savant, he may even be prodigious. His special skills and abilities are highly specialized, and are obviously conspicuous when viewed over against his overall handicap, he can draw in ways that most professional artists would find impossible. Tim seems to fit with one view of savant syndrome as resulting from a compensation for a sensory deficit, i.e. his deafness, and the possession of a remarkable photographic memory. My wife has adopted the position that Tim’s drawing ability would not have become so apparent if the communication barriers had not been bridged. Tim has a need to be sure of, and trust, what is happening around him. Without this need being met, Tim’s exceptional abilities would not have had the chance to develop in the way that they have. Indeed, it is highly unlikely that they would ever have been noticed at all.

# References


Questions

1. What is the purpose of Hiles’ inclusion of the specific example?
   Hiles includes descriptions of Tim’s condition in order to provide the reader with real context of the savant symptoms. The table of observations show how the symptoms arise in real situations. Now the readers can recognize some similarities in people around them. In addition, Hiles shows that he spent a lot of time with savants and knew Tim personally which adds to his ethos and credibility.

2. Why does Hiles also describe autism?
   Autism is a disorder that is closely linked with savant syndrome but there are some ambiguities regarding the relation of the two conditions. Hiles tries to clear them up; he writes that autistic savant is a term that is widely used and many savants exhibit autistic like characteristics, but not all savants are autistic.

3. Why does Hiles say that only a few savants are recognized?
   Hiles divides savant skills into three categories: splinter, talented, and prodigious. Prodigious savants are much rarer, where the ability or brilliance is not only spectacular in contrast to the disability, but would be spectacular even if viewed in a non-disabled person. Most of the time, only the prodigious savants are “discovered.”

4. Why does Hiles list two conditions for being a savant?
   Hiles observed that savants must not only be incredibly good at a specific skill but they must also be compelled to do it constantly, as if driven by an intense desire. This way he separate the extremely gifted from true savants.
When Brain Damage Unlocks the Genius Within
Adam Piore

About the Author:
Adam Piore is an award-winning journalist based in New York. A former editor and correspondent for Newsweek Magazine, his narrative features have appeared in GQ, Discover Magazine, Mother Jones, Scientific American, BusinessWeek and many others. Piore has a Masters of Science from Columbia University School of Journalism, and Bachelor of Arts in Psychology from the University of California at Santa Cruz. “When Brain Damage Unlocks the Genius Within” was originally published in the March 2013 issue of Popular Science magazine. The article primarily describes acquired savants—people who unlock savant abilities after severe head trauma. Piore notes a new experiment that deactivated parts of the brain for a small period of time and seemed to produce savant like abilities in the normal test subjects. Unlike the other authors, Piore also talks about the commercial appeal of savants and society’s interest in the condition. Piore writes how the remarkable abilities rocketed savants into fame when they would have otherwise led a disadvantaged life.

Derek Amato stood above the shallow end of the swimming pool and called for his buddy in the Jacuzzi to toss him the football. Then he launched himself through the air, head first, arms outstretched. He figured he could roll onto one shoulder as he snagged the ball, then slide across the water. It was a grave miscalculation. The tips of Amato's fingers brushed the pigskin—then his head slammed into the pool's concrete floor with such bone-jarring force that it felt like an explosion. He pushed to the surface, clapping his hands to his head, convinced that the water streaming down his cheeks was blood gushing from his ears.

At the edge of the pool, Amato collapsed into the arms of his friends, Bill Peterson and Rick Sturm. It was 2006, and the 39-year-old sales trainer was visiting his hometown of Sioux Falls, South Dakota, from Colorado, where he lived. As his two high-school buddies drove Amato to his mother's home, he drifted in and out of consciousness, insisting that he was a professional baseball player late for spring training in Phoenix. Amato's mother rushed him to the emergency room, where doctors diagnosed Amato with a severe concussion. They sent him home with instructions to be woken every few hours. It would be weeks before the full impact of Amato's head trauma became apparent: 35 percent hearing loss in one ear, headaches, memory loss. But the most dramatic consequence appeared just four days after his accident. Amato awoke hazy after near-continuous sleep and headed over to Sturm's house. As the two pals sat chatting in Sturm's makeshift music studio, Amato spotted a cheap electric keyboard.

Without thinking, he rose from his chair and sat in front of it. He had never played the piano—never had the slightest inclination to. Now his fingers seemed to find the keys by instinct and, to his astonishment, ripple across them. His right hand started low, climbing in lyrical chains of triads, skipping across
melodic intervals and arpeggios, landing on the high notes, then starting low again and building back up. His left hand followed close behind, laying down bass, picking out harmony. Amato sped up, slowed down, let pensive tones hang in the air, then resolved them into rich chords as if he had been playing for years. When Amato finally looked up, Sturm's eyes were filled with tears.

Music Man

An accident left Derek Amato with a severe concussion and a surprising ability to play the piano. One theory is that his brain reorganized, making accessible existing memories of music. Another is that his brain no longer filters sensory input, enabling him to hear individual notes rather than melodies.

Amato played for six hours, leaving Sturm's house early the next morning with an unshakable feeling of wonder. He searched the Internet for an explanation, typing in words like gifted and head trauma. The results astonished him.

He read about Tony Cicoria, an orthopedic surgeon in upstate New York who was struck by lightning while talking to his mother from a telephone booth. Cicoria then became obsessed with classical piano and taught himself how to play and compose music. After being hit in the head with a baseball at age 10, Orlando Serrell could name the day of the week for any given date. A bad fall at age three left Alonzo Clemons with permanent cognitive impairment, Amato learned, and a talent for sculpting intricate replicas of animals.

Finally Amato found the name Darold Treffert, a world-recognized expert on savant syndrome—a condition in which individuals who are typically mentally impaired demonstrate remarkable skills. Amato fired off an e-mail; soon he had answers. Treffert, now retired from the University of Wisconsin School of Medicine, diagnosed Amato with "acquired savant syndrome." In the 30 or so known cases, ordinary people who suffer brain trauma suddenly develop almost-superhuman new abilities: artistic brilliance, mathematical mastery, photographic memory. One acquired savant, a high-school dropout brutally beaten by muggers, is the only known person in the world able to draw complex geometric patterns called fractals; he also claims to have discovered a mistake in pi. A stroke transformed another from a mild-mannered chiropractor into a celebrated visual artist whose work has appeared in publications like The New Yorker and in gallery shows, and sells for thousands of dollars.

The neurological causes of acquired savant syndrome are poorly understood. But the Internet has made it easier for people like Amato to connect with researchers who study savants, and improved brain-imaging techniques have enabled those scientists to begin to probe the unique neural mechanisms at work. Some have even begun to design experiments that investigate an intriguing possibility: genius lies in all of us, just waiting to be unleashed.

* * *
Pure Genius

Bruce Miller directs the UCSF Memory and Aging Center in San Francisco, where as a behavioral neurologist he treats elderly people stricken with Alzheimer's disease and late-life psychosis. One day in the mid-1990s, the son of a patient pointed out his father's new obsession with painting. As his father's symptoms worsened, the man said, his paintings improved. Soon, Miller began to identify other patients who displayed unexpected new talents as their neurological degeneration continued. As dementia laid waste to brain regions associated with language, higher-order processing, and social norms, their artistic abilities exploded.

Though these symptoms defied conventional wisdom on brain disease in the elderly—artists afflicted with Alzheimer's typically lose artistic ability—Miller realized they were consistent with another population described in the literature: savants. That wasn't the only similarity. Savants often display an obsessive compulsion to perform their special skill, and they exhibit deficits in social and language behaviors, defects present in dementia patients. Miller wondered if there might be neurological similarities too. Although the exact mechanisms at work in the brains of savants have never been identified and can vary from case to case, several studies dating back to at least the 1970s have found left-hemispheric damage in autistic savants with prodigious artistic, mathematical, and memory skills.

Sudden Sculptor

After suffering a head injury as a toddler, Alonzo Clemons began to spontaneously sculpt animals with incredible accuracy and speed.

Miller decided to find out precisely where in the left hemisphere of regular savants—whose skills usually become apparent at a very young age—these defects existed. He read the brain scan of a five-year-old autistic savant able to reproduce intricate scenes from memory on an Etch-a-Sketch. Single-photon-emission computed tomography (SPECT) showed abnormal inactivity in the anterior temporal lobes of the left hemisphere—exactly the results he found in his dementia patients.

In most cases, scientists attribute enhanced brain activity to neuroplasticity, the organ's ability to devote more cortical real estate to developing skills as they improve with practice. But Miller offered a wholly different hypothesis for the mechanisms at work in congenital and acquired savants. Savant skills, Miller argues, emerge because the areas ravaged by disease—those associated with logic, verbal communication, and comprehension—have actually been inhibiting latent artistic abilities present in those people all along. As the left brain goes dark, the circuits keeping the right brain in check disappear. The skills do not emerge as a result of newly acquired brain power; they emerge because for the first time, the areas of the right brain associated with creativity can operate unchecked.
Full Spectrum

Savant skills lie on a spectrum of ability; Clemons is considered the rare prodigious savant—one whose talent would be exceptional even for a person not impaired in any way.

The theory fits with the work of other neurologists, who are increasingly finding cases in which brain damage has spontaneously, and seemingly counterintuitively, led to positive changes—eliminating stuttering, enhancing memory in monkeys and rats, even restoring lost eyesight in animals. In a healthy brain, the ability of different neural circuits to both excite and inhibit one another plays a critical role in efficient function. But in the brains of dementia patients and some autistic savants, the lack of inhibition in areas associated with creativity led to keen artistic expression and an almost compulsive urge to create.

* * *

In the weeks after his accident, Amato's mind raced. And his fingers wanted to move. He found himself tapping out patterns, waking up from naps with his fingers drumming against his legs. He bought a keyboard. Without one, he felt anxious, overstimulated; once he was able to sit down and play, relief washed over him, followed by a deep sense of calm. He'd shut himself in, sometimes for as long as two to three days, just him and the piano, exploring his new talent, trying to understand it, letting the music pour out of him.

Amato experienced other symptoms, many of them not good. Black and white squares appeared in his vision, as if a transparent filter had synthesized before his eyes, and moved in a circular pattern. He was also plagued with headaches. The first one hit three weeks after his accident, but soon Amato was having as many as five a day. They made his head pound, and light and noise were excruciating. One day, he collapsed in his brother's bathroom. On another, he almost passed out in Wal-Mart.

Still, Amato's feelings were unambiguous. He felt certain he had been given a gift, and it wasn't just the personal gratification of music: Amato's new condition, he quickly realized, had vast commercial potential.

Tortured Artist

Jon Sarkin says he saw things differently, more vividly, after suffering a brain hemorrhage and a stroke. And while the chiropractor had always dabbled in art, he suddenly became obsessed with
Cultural fascination with savants appears to date as far back as the condition itself. In the 19th century, "Blind Tom" Bethune became an international celebrity. A former slave who could reproduce any song on the piano, he played the White House at age 11, toured the world at 16, and over the course of his life earned well over $750,000—a fortune at the time. Dustin Hoffman introduced the savant to millions of theatergoers with his character in the 1988 movie Rain Man. Since then, prodigious savants have become staples of shows like 60 Minutes and Oprah. But acquired savants, especially, are perfect fodder for a society obsessed with self-improvement, reality television, and pop psychology.

Jon Sarkin, the chiropractor turned artist, became the subject of profiles in GQ and Vanity Fair, a biography, and TV documentaries. Tom Cruise purchased the rights to his life story. "To be honest, I don't even mention it to my wife anymore when the media calls," Sarkin says. "It's part of life." Jason Padgett, the savant who can draw fractals, inked a book deal after he was featured on Nightline and in magazine and newspaper articles. Reached by phone, he complained that his agent no longer allowed him to give interviews. "It's very frustrating," he said. "I want to speak to you, but they won't let me." To Amato, acquired savantism looked like the opportunity he'd been waiting for his entire life. Amato's mother had always told him he was extraordinary, that he was put on the planet to do great things. Yet a series of uninspiring jobs had followed high school—selling cars, delivering mail, doing public relations. He'd reached for the brass ring, to be sure, but it had always eluded him. He'd auditioned for the television show American Gladiators and failed the pull-up test. He'd opened a sports-management company, handling marketing and endorsements for mixed-martial-arts fighters; it went bust in 2001. Now he had a new path.

From Chiropractor To Painter

"Eight years ago, I didn't draw for a while and I found out what happened," Sarkin says. "I had a nervous breakdown. And I have been drawing pretty much constantly ever since."

Amato began planning a marketing campaign. He wanted to be more than an artist, musician, and performer. He wanted to tell his story and inspire people. Amato also had another ambition, a goal lingering from his life before virtuosity, back when he had only his competitive drive. He wanted, more than anything, to be on Survivor. So when that first interviewer called from a local radio station, Amato was ready to talk.
Few people have followed the emergence of acquired savants with more interest than Allan Snyder, a neuroscientist at the University of Sydney in Australia. Since 1999, Snyder has focused his research on studying how their brains function. He's also pressed further into speculative territory than most neuroscientists feel comfortable: He is attempting to produce the same outstanding abilities in people with undamaged brains.

Last spring, Snyder published what many consider to be his most substantive work. He and his colleagues gave 28 volunteers a geometric puzzle that has stumped laboratory subjects for more than 50 years. The challenge: Connect nine dots, arrayed in three rows of three, using four straight lines without retracing a line or lifting the pen. None of the subjects could solve the problem. Then Snyder and his colleagues used a technique called transcranial direct current stimulation (tDCS) to temporarily immobilize the same area of the brain destroyed by dementia in Miller's acquired savants. The noninvasive technique, which is commonly used to evaluate brain damage in stroke patients, delivers a weak electrical current to the scalp through electrodes, depolarizing or hyperpolarizing neural circuits until they have slowed to a crawl. After tDCS, more than 40 percent of the participants in Snyder's experiment solved the problem. (None of those in a control group given placebo tDCS identified the solution.)

Sarkin's Art

The experiment, Snyder argues, supports the hypothesis that the abilities observed in acquired savants emerge once brain areas normally held in check have become unfettered. The crucial role of the left temporal lobe, he believes, is to filter what would otherwise be a dizzying flood of sensory stimuli, sorting them into previously learned concepts. These concepts, or what Snyder calls mind-sets, allow humans to see a tree instead of all its individual leaves and to recognize words instead of just the letters. "How could we possibly deal with the world if we had to analyze, to completely fathom, every new snapshot?" he says.

Savants can access raw sensory information, normally off-limits to the conscious mind, because the brain's perceptual region isn't functioning. To solve the nine-dot puzzle, one must extend the lines beyond the square formed by the dots, which requires casting aside preconceived notions of the parameters. "Our whole brain is geared to making predictions so we can function rapidly in this world," Snyder says. "If something naturally helps you get around the filters of these mind-sets, that is pretty powerful."

Sudden Savant
Treffert, for one, finds the results of the experiment compelling. "I was a little dubious of Snyder's earlier work, which often involved asking his subjects to draw pictures," he says. "It just seemed pretty subjective: How do you evaluate the change in them? But his recent study is useful."

Snyder thinks Amato's musical prodigy adds to mounting evidence that untapped human potential lies in everyone, accessible with the right tools. When the non-musician hears music, he perceives the big picture, melodies. Amato, Snyder says, has a "literal" experience of music—he hears individual notes. Miller's dementia patients have technical artistic skill because they are drawing what they see: details. Berit Brogaard believes the left-brain, right-brain idea is an oversimplification. Brogaard is a neuroscientist and philosophy professor at the Center for Neurodynamics at the University of Missouri–St. Louis. She has another theory: When brain cells die, they release a barrage of neurotransmitters, and this deluge of potent chemicals may actually rewire parts of the brain, opening up new neural pathways into areas previously unavailable.

"Our hypothesis is that we have abilities that we cannot access," Brogaard says. "Because they are not conscious to us, we cannot manipulate them. Some reorganization takes place that makes it possible to consciously access information that was there, lying dormant."

In August, Brogaard published a paper exploring the implications of a battery of tests her lab ran on Jason Padgett. It revealed damage in the visual-cortex areas involved in detecting motion and boundaries. Areas of the parietal cortex associated with novel visual images, mathematics, and action planning were abnormally active. In Padgett's case, she says, the areas that have become supercharged are next to those that sustained the damage—placing them in the path of the neurotransmitters likely unleashed by the death of so many brain cells.

In Amato's case, she says, he learned bar chords on a guitar in high school and even played in a garage band. "Obviously he had some interest in music before, and his brain probably recorded some music unconsciously," she says. "He stored memories of music in his brain, but he didn't access them."

Somehow the accident provoked a reorganization of neurons that brought them into his conscious mind, Brogaard speculates. It's a theory she hopes to explore with him in the lab.

* * *

On a beautiful Los Angeles day last October, I accompanied Amato and his agent, Melody Pinkerton, up to the penthouse roof deck of Santa Monica's Shangri-La Hotel. Far below us, a pier jutted into the ocean and the Pacific Coast Highway hugged the coastline. Pinkerton settled next to Amato on a couch, nodding warmly and blinking at him with a doe-eyed smile as three men with handheld cameras circled. They were gathering footage for the pilot of a reality-TV series about women trying to make it in Hollywood. Pinkerton is a former contestant on the VH1 reality show Frank the Entertainer and has posed for Playboy; if the series is green-lit, Amato will make regular appearances as one of her clients.

"My whole life has changed," Amato told her. "I've slowed down, even though I'm racing and producing at a pace that not many people understand, you know? If Beethoven scored 500 songs a year back in the day and was considered a pretty brilliant mind, and the doctors tell me I'm scoring 2,500 pieces a year, you can see that I'm a little busy."

Amato seemed comfortable with the cameras, despite the pressure. A spot on a reality show would
represent a step forward in his career, but not a huge leap. Over the past six years, Amato has been featured in newspapers and television shows around the world. He was one of eight savants featured on a Discovery Channel special in 2010 called *Ingenious Minds*, and he was on PBS's *NOVA* this fall. He recently appeared on a talk show hosted by his idol, Jeff Probst, also the host of *Survivor*. In June, Amato appeared on the *Today* show.

Many savants exhibit exquisite computational or artistic capacities, but almost always at the expense of other things the brain does.

Musical renown (and a payday) has yet to follow. He released his first album in 2007. In 2008, he played in front of several thousand people in New Orleans with the famed jazz-fusion guitarist Stanley Jordan. He was asked to write the score for an independent Japanese documentary. But while Amato's musical prowess never fails to elicit amazement in the media, reviews of his music are mixed. "Some of the reaction is good, some of it's fair, some of it's not so good," he says. "I wouldn't say any of it's great. What I think's going to be great is working with other musicians now."

Still, as we strolled down Santa Monica Boulevard to a sushi restaurant after the filming, he hardly could have seemed happier. At the table, Amato smiled broadly, gestured manically with meaty forearms tattooed with musical notes, and poked the air with his chopsticks for emphasis. "There's book stuff, there are appearances, performances, charity organizations," he said. "There are TV people, film people, commercial people, background stuff. Shoot, I know I missed about another half dozen. It's like I'm on a plane doing about 972 miles an hour! I'm enjoying every second of the ride!"

Amato hasn't exactly been coy about his desire for fame, mailing packets of material to reporters, sending Facebook requests to fellow acquired savants, and continuously updating his fan page—behavior that has raised some doubts among experts.

Rex Jung, a neuroscientist at the University of New Mexico, grew suspicious of Amato after reading about his history as an ultimate-fight promoter. "I couldn't be more skeptical," he says. Jung studies creativity and traumatic brain injuries, and he has spent time with Alonzo Clemons, the savant who sculpts animals. He believes acquired savantism is a legitimate condition. But he notes Amato does not display other symptoms one would expect.

Many savants, Jung says, exhibit "exquisite" computational or artistic capacities, but "almost always at the expense of other things the brain does." Clemons, for example, has severe developmental disabilities. "I am highly skeptical of savants that are able to tie their shoes and update their Facebook pages and do strong marketing campaigns to highlight their savant abilities all at the same time."

**Overnight Artist**

There is no way to definitively prove or disprove Amato's claims, but a number of credible scientists are willing to vouch for his authenticity. Andrew Reeves, a neurologist at the Mayo Clinic, conducted MRI scans of Amato's brain for *Ingenious Minds*. The tests revealed several white spots, which Reeves
acknowledges could have been caused by previous concussions.
"We knew going in that it was unlikely to show any sort of signature change," Reeves says. But Amato's description of what he experiences "fits too well with how the brain is wired, in terms of what parts are adjacent to what parts, for him to have concocted it, in my opinion." Reeves believes the black and white squares in Amato's field of vision somehow connect to his motor system, indicating an atypical link between the visual and auditory regions of his brain.

As I drove through the streets of L.A. with Amato last fall, it seemed to me that there was something undeniably American about his efforts to seize on his accident—which struck when he was close to 40, staring into the abyss of middle-age mediocrity—and transform himself from an anonymous sales trainer into a commercial product, an inspirational symbol of human possibility for the legions of potential fans dreaming of grander things. Treffert, Snyder, and Brogaard all spoke enthusiastically about unraveling the phenomenon of acquired savantism, in order to one day enable everyone to explore their hidden talents. The Derek Amatos of the world provide a glimpse of that goal.

After parking on Sunset Boulevard, a few blocks from the storied rock-and-roll shrines of the Roxy and the Viper Room, Amato and I headed into the Standard Hotel and followed a bedraggled hipster with an Australian accent through the lobby to a dimly lit bar. In the center of the room sat a grand piano, its ivory keys gleaming. The chairs had been flipped upside down on the tables, and dishes clinked in a nearby kitchen. The club, closed to customers, was all ours. As Amato sat down, the tension seemed to drain from his shoulders.

He closed his eyes, placed his foot on one of the pedals, and began to play. The music that gushed forth was loungy, full of flowery trills, swelling and sweeping up and down the keys in waves of cascading notes—a sticky, emotional kind of music more appropriate for the romantic climax of a movie like From Here to Eternity than a gloomy nightclub down the street from the heart of the Sunset Strip. It seemed strangely out of character for a man whose sartorial choices bring to mind '80s hair-band icon Bret Michaels. Amato didn't strike me as prodigious, the kind of rare savant, like Blind Tom Bethune, whose skills would be impressive even in someone with years of training.

But it didn't seem to matter. There was expression, melody, and skill. And if they could emerge spontaneously in Amato, who's to say what spectacular abilities might lie dormant in the rest of us?

Questions

1. What is the effect of ending the article with a question?
   Piore provokes further thought and pondering from the reader. The reader further considers the potential that savants have to unlock such incredible abilities in all of us. The reader even wonders if he will one day have a savant ability himself.

2. Why does Piore mention the commercial appeal of sudden savant abilities?
   Piore wants to note society’s intense interest in savant syndrome. Society is obsessed with the idea of perfection, thus people are always looking for ways to become the best version of
themselves. Unlocking savant abilities could make normal people smarter, more artistic, more
talented. It could open a whole new science fiction like realm of potential for humans.

3. What is the tone of this article?
Compared with most of the other articles in this anthology, this article is more casual and
relaxed. It is less didactic but lends a more personal and relatable angle to the topic. Piore
describes the time he has spent with Derek Amato and humanizes these incredible savant figures
for the readers. Derek was once a normal guy, just like the reader.

4. Why does Piore focus on acquired savants?
Piore focuses only on people who have acquired savant abilities after some kind of mental
trauma or accident because these people were once average. They were not born with
extraordinary talents. Somehow, they were able to unlock a normally controlled part of their
brains to function with seemingly superhuman ability. They are the keys to finding such abilities
for normal people.
Is there a savant inside all of us?
William Langley

About the Author:
William Langley is a regular writer for the Telegraph, a daily newspaper in the UK. He also writes the Sunday Telegraph’s weekly Profile. In this article which appeared in the Telegraph and SEVEN magazine, Langley describes the experiences of three sudden savants who gained their abilities after traumatic head injuries. He inquires whether we all have such abilities in us lying dormant but waiting to be triggered. Langley also touches upon a theory that some savants—such as musical savants—may have been able to access knowledge that was passed on to them through DNA. Dr. Treffert is consulted for more insight.

Savants have almost super-human abilities in art, music or memory – and not all are born that way. But is severe head trauma the only way to become a ‘sudden savant’?

On Southport’s stately seafront, the opening of a new art exhibition is drawing a late summer crowd. Long and unusually complex in the planning, it features the paintings of Tommy McHugh, an ex-builder from nearby Liverpool whose work has attracted worldwide attention. Despite the appreciative buzz, Tommy, unfortunately, can’t be present. I later find him in the intensive care unit of a hospital on the Wirral, where he has been taken with acute pneumonia. A few weeks later he is dead. The redoubtable, 62 year-old latecomer to the world of art had been plagued with illness for some time, but harboured mixed feelings about his afflictions. It was after a near-fatal stroke, 11 years ago, that he discovered – to no one’s greater surprise than his own – that he could paint. And paint not just as an occasional pleasure, but with a furious, obsessive exactness that took over his life and produced a stream of acclaimed works. Psychologists, who looked at his case, considered him to be one of the world’s foremost examples of “sudden savant syndrome” – a rare, barely-understood phenomenon whereby damage to the brain somehow unlocks a hidden talent. There are so few confirmed cases — perhaps 30 in the world – that plausible explanations are hard to come by. Take Orlando Serrell, a 44-year-old from Virginia who was hit on the head by a baseball as a boy, and later found he could do complicated calculations and remember the precise weather conditions of any given day of the year. Or Tony Cicoria. An orthopaedic surgeon from New York State, Dr Cicoria was struck by lightning in 1994 as he chatted to his mother from an outdoor telephone booth. Within weeks he became obsessed with classical piano music and a few years later — despite no previous interest in music beyond listening to rock songs – he made his public debut as a pianist and composer in a solo recital. What is the explanation for all this? And does it – as some scientists now believe – hold the promise of unleashing the inner talents of everyone?
“What appears to happen,” says Darold Treffert, a consultant psychiatrist from Wisconsin who has studied such cases for 40 years, “is that after severe trauma the brain rewires itself. When damage occurs in one part of the brain it may be that other parts step in to compensate and in doing so release dormant potential which manifests itself as abilities that weren’t there – or weren’t known about – before.”

McHugh’s upbringing wasn’t the kind that nurtured an appreciation of arts and high culture. One of 12 children born into a working-class family, he was in regular trouble as a young man, fell into drug use, served time in prison, and eventually made a career of sorts as a builder and odd-job man. No one would have thought that his appreciation of art went beyond the tattoos on his forearms. But in 2001 Tommy suffered a severe stroke, with haemorrhaging on both sides of his brain. When he returned home he had no idea who he was. The face in the mirror was one he didn’t recognise. The woman who said she was his wife was a stranger. He found he could only speak in an elaborate form of rhyme.

Then, as he groped around in a world he no longer knew, the emptiness was replaced by a huge, urgent creative rush. He began painting and hasn’t stopped. He covered the walls, the doors and the ceilings of his house in vivid, intricate patterns and when he ran out of space, he re-covered what he had already painted. “It was as though a balloon had popped,” he told me, propped up in a bed in Arrow Park Hospital. “I could see the beauty of the world. I knew who I was. The man I used to be had gone forever. I don’t even know who he was.” Tommy produced not only paintings, but sculptures and collages, and his rhymes began to fashion themselves into poetry.

Dr Mark Lythgoe, a neurologist at University College London, who has studied the McHugh case, says: “It may be that the brain damage that Tommy sustained has caused disinhibition of brain pathways, allowing his creativity to surface. Perhaps whatever was keeping his artistic talents hidden or dormant has been damaged just enough to allow them to pour through.”

Tommy himself spoke like a born-again convert, desperate for others to hear the Good News. “This isn’t something special to me,” he said. “This is inside everyone, but they are too frightened to let it out. Then something happens to you and it comes out anyway.”

The results are sometimes bizarre. Last year, Chris Birch, a 19-stone rugby player from South Wales, told how he suffered a stroke and woke up gay. The 26-year-old proceeded to ditch his girlfriend, pack in his job and retrain as a hairdresser. Other patients have started speaking in foreign accents. But researchers are most interested in those who wake up with savant-type abilities.

In 2003, Bruce Miller, a professor of neurology at the University of California, San Francisco, discovered that some patients suffering from a degenerative brain disorder called frontotemporal dementia (FTD), developed sudden and remarkable artistic talents as their conditions progressed. One of the cases he studied involved Anne Adams, a renowned Canadian biologist, who – as FTD gnawed at the cognitive networks of her brain – lost the power of speech, but gained extraordinary artistic skills. “This shows how plastic our brain is,” explained Miller in a report published in the magazine Brain four years ago. “If you turn off the language circuits, you may have increased activities in other areas.”

Elsewhere, scientists are now investigating whether it’s possible to replicate this change without, of
course, damaging the patient. Dr Allan Snyder, of the University of Sydney, has created a machine called the Medronic MagPro which attempts temporarily to replicate the deterioration caused by FTD, by sending precise electromagnetic pulses into the frontal lobes of the brain. Snyder calls it “a creativity amplification machine”.

One guinea pig who underwent Snyder’s tests was asked to draw a sequence of pictures of cats. He reported: “Two minutes after I started the first drawing, I was instructed to try again. After another two minutes I tried a third cat, and then in due course a fourth. Then the experiment was over, and the electrodes were removed. I looked down at my work. The first felines were boxy and stiffly unconvincing, but after I had been subjected to about 10 minutes of transcranial magnetic stimulation, their tails had grown more vibrant; their faces were personable and convincing.” Other patients, says Snyder, have experienced enhanced abilities in memory, visual skills and mathematical calculation.

Savants are usually defined as people – predominantly men – who possess unusual powers of memory, calculation or artistic skill in conjunction with severe mental deficiencies. The condition presents in men much more often than in women because, according to some scientists, high levels of testosterone in the male foetus cause damage to the left hemisphere of the brain. Treffert describes savant abilities as “deep but narrow”, and many struggle with the wider challenges of life. Sudden savant syndrome appears to add a further dimension to the phenomenon, as most have had relatively normal lives until the savantism hits them.

If there is a Leonardo lurking in all of us, or a Mozart writing silent scores in our heads, it raises one big, so far unanswered question: where does such talent come from? How can someone such as Cicoria, who had undergone no musical training or demonstrated any previous hint of talent, suddenly start composing sonatas and concertos?

The consensus-shattering answer may lie in genetics. “The only way this can be explained,” says Treffert, “is through the genetic transmission of knowledge. We know this is the case in the animal kingdom; creatures manage incredible feats of navigation [without anyone] teaching them how to do it. Someone in the family of a Tommy McHugh must have had these abilities.” This theory vastly expands existing assumptions of what human DNA can do. But even if it can be proved, it’s hard to explain the astonishing capabilities of men like Orlando Serrell.

Serrell is currently out of work, having recently lost his job as a caretaker in Newport News, Virginia. He tells me he had hoped his abilities would open up opportunities, possibly with the FBI or even as a stage novelty act, but after an initial burst of interest, nothing has developed.

“Some people, you know, they lose consciousness, go into a coma, things like that, and when they wake up, they find they are different people,” he says. “But it wasn’t like that with me. I was playing in the park, and someone threw [a] baseball and it hit me at the front of the head, but I wasn’t knocked out. I just lay down and my head hurt bad, but I got up and carried on the game, and it was only about a month later that I found I could do this stuff.”

What Serrell can do is instantaneously put a day to any date since the accident and recall the weather, where he was and what he was doing. Doctors who have studied him say this ability is vastly beyond the capacity of normal human memory. Nothing known to science explains it, and it is hard to see how
genetics could.

“I’m the same guy,” he says. “I don’t feel different in any other way. I don’t even think of myself as a savant, I just feel I have a gift that I found by accident. Beyond that I can’t explain it.” Nor, adequately, can Cicoria.

A self-described “rock-and-roll kind of guy”, Cicoria, whose story was recounted in the neurologist Oliver Sacksʼs 2007 book, Musicophilia: Tales of Music and the Brain, recovered from the physical effects of the lightning strike but soon began to feel strange activity in his brain: “like it was one of those old-fashioned TV sets that picked up interference, and you had to whack it to get a good picture.”

What came out of the fuzz and crackle was a sudden desire for the finest classical piano music. “I might be a respectable physician on the outside, but inside I’m a biker dude,” he says. “I’d had a couple of music lessons when I was a kid, but that was all. I couldn’t understand why I wanted to hear this stuff. So I went to the music store, and bought some CDs, and then I felt that wasn’t enough and I wanted to play it for myself, so I bought the sheet music and then a piano, and began to learn how to play.

“Then, as I played, other music started coming through in my head, and I understood that I needed to write it down.” Today, Dr Cicoria, 60, is an accomplished composer and pianist who has given dozens of well-received recitals. “Exactly what happened to me, I’ll never know,” he says, “but I’m glad it did.”

This is how it tends to be in the world of the savants. Brilliance and talent abound, but no one can quite explain what is going on.

Questions

1. How does Langley explain the phenomena of the acquired savant?
Langley uses plenty of detailed narrations to tell the stories of the savants rather than explain using purely scientific jargon which would make the reader feel far removed from the seemingly unfathomable abilities of the savants.

2. How does Langley use language to describe the new world that sudden savants experience after their accidents?
Langley uses precise and emotive diction to create vivid imagery to depict the heightened and more intense worlds of savants. Langley describes one savant’s sudden urge to paint as “not just as an occasional pleasure, but [...] a furious, obsessive exactness that took over his life and produced a stream of acclaimed works.”

3. How does Langley add ethos and legitimacy to his piece?
Langley speaks with and quotes Dr. Treffert, a savant expert, Dr. Lythgoe, a neurologist, and Bruce Miller, professor of neurology. Langley also adds specific and detailed descriptions of studies done about savant syndrome.

4. Why does Langley mention in such detail the backgrounds of the savants?
Langley wants to emphasize how random and out of the blue their new abilities were. McHugh had a background that would never have pointed to a future in piano. Cicoria loved rock and roll before his accident morphed him into a piano virtuoso. Langley juxtaposes their pasts and presents to increase the fantasticality of their new abilities.
Kim Peek: The Real Rain Man
Focus Productions
2006 UK

About the Documentary:
Focus TV production is headed by Martin Weitz who has a BA Honors degree in Psychology and Philosophy from University College, Oxford. He began his career at Granada TV and then worked on many World In Action investigative films and BBC 2’s Horizon series. In the award winning movie Rain Man, Dustin Hoffman portrays memorable Raymond Babbit, an autistic savant. This documentary movie tells the story of Kim Peek- the real life Rain Man who had memorized 12,000 books, but needed his father’s help with mundane tasks like getting dressed and combing his hair. Peek could read one page of a book with his left eye and the other with his right; in just eight seconds he could read and remember the page. Peek was classified as a genius in fifteen different subjects, yet still scored below average in IQ tests. During his preparation for the role Hoffman met Mr. Peek, and helped him to overcome his deeply introverted nature. This documentary tells the story of the first well known savant, the man who made savant syndrome famous.

Questions
1. Why does the documentary include Peek’s father?
   Though Peek is a classified genius, he still needs his father to help him get dressed and perform everyday tasks. It emphasizes the contrast between his incredible gift and his unfortunate impairment. Peek’s father is also getting older and it foreshadows how Peek’s life will be without his father.

2. Why did the producer include the suggestion about putting Peek in the mental institution?
   When Peek was a child, many doctors told his parents that he should be put in the mental institution. It shows that savants and people with autism are misunderstood. Had he been shut away, Peek’s genius would never have been discovered.

3. Why was the test with Dr. Paul included?
   The documentary again shows Peek’s memory contradicted with his social impairment. He can memorize encyclopedias of facts but he can only use very simple social formulas. He really wants to connect with people but he doesn’t socially connect like we do.

4. Why does the documentary go to the library?
   The library is Peek’s favorite place and is likely where his gift developed and was recognized. Peek can read pages in seconds and then catalog all the information in his mind. The library is where his ability came into fruition.
About the Documentary:

*Ingenious Minds* is a documentary television anthology series about savants that debuted in the United States in 2010. It was broadcast on Science Channel, part of Discovery Communications, with each episode lasting 30 minutes. This episode is about Derek Amato who acquired musical savant abilities after a pool accident when he dived into the shallow end and hit his head. Derek had never before known how to play piano until one day after his accident when he just sat down at the bench and began to play like a master.

Questions

1. Why does the camera show the black and white blocks Amato describes?
   The documentary tries to simulate what Amato sees as he plays music. It isn’t anything like the conscious sight reading that normal piano players experience. It is also constant for Amato, it doesn’t stop until he plays.

2. Why is Amato’s best friend interviewed?
   Amato’s best friend knew him before and after the accident and could say how he had changed. The best friend was there when the accident happened and knew that Amato did not previously know how to play piano. Another person adds credibility to the story.

3. Why is Amato’s CAT scan included?
   The CAT scan shows the damage to the brain that triggered Amato’s new talent. It was also mentioned that Amato had a history of concussions from a very athletic young life which probably also contributed to him damaging enough of his brain to unlock a dormant part.

4. What’s the purpose of the scene when Amato must stop the car and go to the nearest piano to play?
   Amato enjoys his newfound talent and would not wish for it to change but it is not all good times. Since the accident he has frequent headaches and the music in his head never stops. He has a veritable need to play. When Amato is not playing, he thinks about it. It’s exhausting.
Extraordinary People: The Human Camera

About the Documentary:

*Extraordinary People* is a television documentary series broadcast on Channel 5 in the United Kingdom. Each program follows the lives of people with rare medical conditions or unusual abilities. This episode is about Stephen Wiltshire, an autistic savant artist, who is called the human camera for his incredible ability to draw detailed pictures of buildings and cities entirely from memory. Wiltshire became one of the best known savants in the world when he appeared on BBC television at just eleven years old. In 2006, Wiltshire was made a Member of the Order of the British Empire (MBE) for services to art. The program looks at his life and his attempt to draw a four meter panorama drawing of London in just five days, based on a fifteen minute helicopter ride above the city.

Questions

1. Why is it included that Stephen must learn to navigate public transit by himself?
   For most everyone, learning to use public transit by themselves is no incredible task but for someone with autism, the noise and confusion can be very troubling. Stephen has learned to travel using transit so that he can go sketching whenever he likes. He has been able to overcome his natural inclination to avoid busy situations and is now a confident and calm man. Stephen can be an example for other savants troubled with autistic symptoms.

2. Why did the producer choose to include a statement from the man from Foster and Partners?
   Stephen loves to draw buildings and architecture and the man from Foster & Partners is an architect and artist himself. He is the same age as Stephen and considers Stephen to be one of the artists he admires most. The man says that he believes we all have the drawing ability inside of us but some have it unlocked to a more advanced degree which is similar to the belief that understanding savants could be the key to unlocking extraordinary abilities in normal people.

3. Why do the camera people interview the photographer and the structural engineer?
   The normal people all marveled at Stephen’s drawing but would not be able to appreciate the incredibly sharp accuracy and detail of the panorama drawing. The photographer and engineer both vouch for the incredible accuracy of the drawing adding to the amazingness of the feat. Each drawn building has the exact number of windows as the real building.

4. Why is footage of Stephen’s early life included?
   The child Stephen was is very different from the man he became. Before drawing became his outlet, Stephen was a very skittish child. He talked very rarely and had an involuntary tick. His drawing allowed him to start communicating and opened up his personality. He became a calm and confident man and overcame his early impairment. The documentary juxtaposes these two
Stephens and shows how drawing had changed him for the better.
Extraordinary People: The Boy With the Incredible Brain

Director: Steve Gooder
Producer: Martin Weitz

About the Documentary:
Extraordinary People is a television documentary series broadcast on Channel 5 in the United Kingdom. Each program follows the lives of people with rare medical conditions or unusual abilities. This episode centers around Daniel Tammet, a math savant who is able to perform massive calculations in his head with seemingly no conscious effort. Tammet experiences synesthesia in which he sees a specific color and shape for every number. When asked to do a calculation, he sees series of the colors and shapes in his mind. Unlike almost all people with savant syndrome, Tammat does not have a crippling social impairment and is able to function normally in society. This fact leads many scientists to believe Tammat is the key to unlocking such abilities in normal humans.

Questions
1. Why does the documentary show colors and shapes as Daniel describes the sensation of synesthesia?
The documentary tries to simulate the sensation for normal people. It tries to show the watchers that Daniel’s calculations are not voluntary but involuntary. The numbers are associated with colors and shapes and they just appear to Tammet, he does no conscious calculation.

2. How does the filming mimic the synesthesia sensation?
When Daniel describes his synesthesia, there are many fast cuts and edits that run across the scene. Colors and shapes fly by and the watcher realizes that this is what Daniel must constantly be experiencing all the time. The camerawork when Daniel enters Las Vegas is also very busy and the watchers have the same unsettling feeling as Daniel as they see all the lights cross the screen.

3. Why does the camera film the calculator as Daniel does math calculations?
The camera follows along as Daniel does the calculation with every single number correct and even surpasses the computer’s limit. It helps convince the watchers that Daniel is not a fake and he is actually performing involuntary calculation.

4. Why are other savants included?
Other savants are included so that Daniel’s abilities do not seem so incredibly super human. There are other people with similar abilities like Kim Peek and Orlando Serrell. It also highlights that Tammet is different from some savants who do have extraordinary abilities but also have
significant social impairments.
Think Better: Tips From a Savant
Jonah Lehrer

About the Author:
Jonah Lehrer is an American author, journalist, blogger, and speaker who writes on the topics of psychology, neuroscience, and the relationship between science and the humanities. He is a contributing editor for Scientific American Mind, editor of Mind Matters and science writer behind the blog The Frontal Cortex and the book Proust Was a Neuroscientist. In this article, Lehrer interviews the math savant, Daniel Tammet who describes what it’s like to be a savant. Tammet describes his synesthesia, his theory of hyperconnectivity and creativity, and tips to improve memory.

Abstract
You may never have the memory of Rain Man, but you can still get tips for improving your cognitive performance from this extraordinary thinker.

Introduction
Daniel Tammet is author of two books, Born on a Blue Day and Embracing the Wide Sky, the latter of which came out in January. He is also a linguist and holds the European record for reciting the first 22,514 digits of the mathematical constant pi. Scientific American Mind contributing editor Jonah Lehrer chats with Tammet about the way his memory works, why the IQ test is overrated, and a possible explanation for extraordinary feats of creativity.

SCIENTIFIC AMERICAN MIND: Your recent memoir, Born on a Blue Day, documented your life as an autistic savant. You describe, for example, how you are able to quickly learn new languages and remember scenes from years earlier in cinematic detail. Are you ever surprised by your own abilities?

DANIEL TAMMET: I have always thought of abstract information—numbers, for example—in visual, dynamic form. Numbers assume complex, multidimensional shapes in my head that I manipulate to form the solution to sums or compare when determining whether they are prime or not.

For languages, I do something similar in terms of thinking of words as belonging to clusters of meaning so that each piece of vocabulary makes sense according to its place in my mental architecture for that language. In this way, I can easily discern relations between words, which helps me to remember them.

In my mind, numbers and words are far more than squiggles of ink on a page. They have form, color, texture, and so on. They come alive to me, which is why as a young child I thought of them as my "friends." I think this is why my memory is very deep, because the information is not static. I say in my
book that I do not crunch numbers (like a computer). Rather I dance with them.

None of this is particularly surprising for me. I have always thought in this way so it seems entirely natural. What I do find surprising is that other people do not think in the same way. I find it hard to imagine a world where numbers and words are not how I experience them!

MIND: In Embracing the Wide Sky, you criticize the IQ test as a vast oversimplification of intelligence. You write: "There is no such thing as proofs of intelligence, only intelligence." Could you explain what you mean by that?

TAMMET: When I was a child, my behavior was far from being what most people would label "intelligent." It was often limited, repetitive and antisocial. I could not do many of the things that most people take for granted, such as looking someone in the eye or deciphering a person's body language, and only acquired these skills with much effort over time. I also struggled to learn many of the techniques for spelling or doing sums taught in class because they did not match my own style of thinking.

I know from my own experience that there is much more to intelligence than an IQ number. In fact, I hesitate to believe that any system could really reflect the complexity and uniqueness of one person's mind or meaningfully describe the nature of his or her potential.

The bell curve distribution for IQ scores tells us that two thirds of the world's population has an IQ somewhere between 85 and 115. This means that some four and a half billion people around the globe share just 31 numerical values ("he's a 94," "you're a 110," "I'm a 103"), equivalent to 150 million people worldwide sharing the same IQ score. This sounds a lot to me like astrology, which lumps everyone into one of 12 signs of the zodiac.

Even if we cannot measure and assign precise values to it in any "scientific" way, I do very much think that intelligence exists and that it varies in the actions of each person. The concept is a useful and important one for scientists and educators alike. My objection is to thinking that any "test" of a person's intelligence is up to the task. Rather we should focus on ensuring that the fundamentals (literacy, etcetera) are well taught and that each child's diverse talents are encouraged and nourished.

MIND: You also describe some recent scientific studies on what happens inside the brain when we learn a second language. Do you think this research should change the way we teach languages?

TAMMET: Thanks to the advances in modern scanning technology, we know more today than ever before just what's happening inside the brain when we're learning a language. That we can speak at all is nothing less than an astonishing cognitive achievement.
Learning a second language, particularly when that language is not one that the person has to use on a regular basis, is an extremely difficult task. I think it is a mistake to underestimate the challenges of it. Students should be aware that the difficulties they will face are inherent in what they are doing and not any failing on their part.

One of the most interesting scientific discoveries about how language works (and how it could be taught) is "phonaesthesia"—that certain sounds have a meaningful relation to the things they describe. For example, in many languages the vowel sound "i" is associated with smallness—little, tiny, petite, niño, and so on—whereas the sound "a" or "o" is associated with largeness—grand, gross, gordo, etcetera. Such links have been found in many of the world's languages. These findings strongly imply that learners would benefit from learning to draw on their own natural intuitions to help them understand and remember many of the foreign words that they come across.

Another finding, by cognitive psychologists Lera Boroditsky, Lauren A. Schmidt and Webb Phillips, might also offer a useful insight into an important part of learning a second language. The researchers asked German and Spanish native speakers to think of adjectives to describe a range of objects, such as a key. The German speakers, for whom the word "key" is masculine, gave adjectives such as "hard," "heavy," "jagged" and "metal," whereas the Spanish speakers, for whom "key" is feminine, gave responses such as "golden," "little," "lovely" and "shiny." This result suggests that native speakers of languages that have gendered nouns remember the different categorization for each by attending to differing characteristics, depending on whether the noun is "male" or "female." It is plausible that second-language learners could learn to perceive various nouns in a similar way to help them remember the correct gender.

Regardless of how exactly a person learns a second language, we do know for sure that it is very good for your brain. There is good evidence that language learning helps individuals to abstract information, focus attention, and may even help ward off age-related declines in mental performance.

MIND: You advocate a theory of creativity defined by a cognitive property you call "hyperconnectivity". Could you explain?

TAMMET: I am unusually creative—from visualizing numerical landscapes composed of random strings of digits to the invention of my own words and concepts in numerous languages. Where does this creativity come from?

My brain has developed a little differently from most other people's. Aside from my high-functioning autism, I also suffered from epileptic seizures as a young child. In my book, I propose a link between my brain's functioning and my creative abilities based on the property of hyperconnectivity.
Rare forms of creative imagination are the result of a convergence of normally disconnected thoughts, memories, feelings and ideas.

In most people, the brain's major functions are performed separately and not allowed to interfere with one another. Scientists have found that in some brain disorders, however, including autism and epilepsy, cross-communication can occur between normally distinct brain regions. My theory is that rare forms of creative imagination are the result of an extraordinary convergence of normally disconnected thoughts, memories, feelings and ideas. Indeed, such hyperconnectivity within the brain may well lie at the heart of all forms of exceptional creativity.

MIND: How were you able to recite from memory the first 22,514 numbers of pi? And do you have advice for people looking to improve their own memory?

TAMMET: As I have already mentioned, numbers to me have their own shapes, colors and textures. Various studies have long demonstrated that being able to visualize information makes it easier to remember. In addition, my number shapes are semantically meaningful, which is to say that I am able to visualize their relation to other numbers. A simple example would be the number 37, which is lumpy like oatmeal, and 111, which is similarly lumpy but also round like the number three (being 37 times 3). Where you might see an endless string of random digits when looking at the decimals of pi, my mind is able to "chunk" groups of these numbers spontaneously into meaningful visual images that constitute their own hierarchy of associations.

Using your imagination is one very good way to improve your own memory. For example, actors who have to remember hundreds or even thousands of lines of a script do so by actively analyzing them and imagining the motivations and goals of their characters. Many also imagine having to explain the meaning of their lines to another person, which has been shown to significantly improve their subsequent recall.

Here is another tip from my book. Researchers have found that you are more likely to remember something if the place or situation in which you are trying to recall the information bears some resemblance—color or smell, for example—to where you originally learned it. A greater awareness therefore of the context in which we acquire a particular piece of information can help improve our ability to remember it later on.

Questions
1. Why is the article written in interview format?
   Rather than occasionally quoting Tammet, Lehrer allows the article to be almost entirely Tammet’s own words because it is a vivid description of Tammet’s own life as a savant.
2. Why does Lehrer ask about Tammet’s opinion on the IQ test?
   Many savants have extraordinary cognitive abilities yet score low on IQ tests. This discrepancy begs the question whether IQ tests are actually an accurate method to measure intelligence. Tammet himself believes not because he did not do well in school during his early years because IQ tests and grades were based on a set way of thinking while Tammet’s way of seeing things was so different.

3. Why does Lehrer ask about second language?
   Language is often overlooked in America’s education system. It is put in the backseat in favor of math or science but is just as intricate, difficult, and indicative of intelligence. Tammet just so happens to be both a math savant who can do enormous calculations and a language savant who can learn any language in a week.

4. Why does Lehrer title the article Think Better: Tips from a Savant?
   The tips from Daniel Tammet actually constitute only a small part of the entire article but people are obsessed with self improvement and this title would attract more readers than a title like A Chat with Daniel Tammet, Math and Language Savant. The readers hope that they can learn to secret to Tammet’s abilities.
Switching Skills On by Turning Off Part of the Brain
Robyn L. Young, Michael C. Ridding, and Tracy L. Morrell

About the Authors:
Robyn Young's interest in autism began while studying savants as part of her PhD at the PDD clinic at Stanford University. Her PhD thesis was described by one of her examiners as the best thesis he had read in 25 years. This work became the subject of an ABC documentary titled Uncommon Genius. She is now a professor at Flinders University. Michael Ridding has a PhD. Corticocortical connections in man from the University of London and is currently a professor at the University of Adelaide. This article describes an experiment in which scientists attempted to test Snyder and Mitchell’s hypothesis that savant abilities could be unlocked in everyone by temporarily disabling a small part of the brain using magnetic pulses in order to mimic acquired savant situations. The participants saw small improvements in their recall, artistic, and other abilities but overall, the results suggest that contrary to the hypothesis these mechanisms are not accessible to everyone and individuals may differ in either their ability to access these mechanisms or even whether they possess such a mechanism(s). These findings also suggest that these skills may be limited to a small percentage of the “normal” population.

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Abstract
Snyder and Mitchell (1999) have argued that the extraordinary skills of savants, including mathematics and drawing, are within us all but cannot normally be accessed without some form of brain damage. It has also been argued that such skills can be made accessible to normal people by switching off part of their brain artificially using magnetic pulses (Carter, 1999). Using repetitive transcranial magnetic stimulation (rTMS) to interrupt the function of the frontotemporal lobe, a region of the brain implicated in the development of savant skills (Miller et al., 1996, 1998), we tested this hypothesis. Here we show that savant-type skills improved in 5 out of 17 participants during the period of stimulation. The enhanced skills included declarative memory, drawing, mathematics, and calendar calculating. In addition to overall improvement being observed, striking improvements in individual performance on various tasks were also seen.

Introduction
Savant syndrome is used to describe individuals who display isolated, exceptional skills despite significant neurological impairment (Nettelbeck and Young, 1999). Our current understanding of intelligence and brain functioning does not extend to include the possibility of this juxtaposition. The examination of savant abilities is therefore of great interest because they challenge current theories about the nature of brain functioning (Nettelbeck and Young, 1999).

While many attempts have been made to explain savants, few have been as unique and provocative as that proposed by Snyder and Mitchell (1999). They propose that savants have access to an unidentified mechanism (e.g., lower level processes and/or information or talent) that underpins their skill. While this in itself is not unique, what makes their hypothesis so exciting is their claim that this mechanism is not restricted to savants but instead resides in all of us. The majority of us, however, are unable to access this mechanism because of interference from higher order cognitive processing. The nature or form of this mechanism is unclear and Snyder and Mitchell (1999) make no attempt to identify it. It remains unclear whether this mechanism is unique to the skill or universal across all skills, with environmental differences such as opportunity, practice, and exposure determining the type of skill that emerges.

This theory alone might seem ambitious if it were not for recent empirical data to support such a proposition. For example, patients with frontotemporal dementia (FTD) who, despite devastating cognitive decline (e.g., short-term memory loss), have developed savant-type skills (Miller et al., 1996, 1998). The emergence of such skills, although rare, is more common in patients with frontotemporal degeneration, specifically in the left hemisphere where the anterior temporal lobes are dysfunctional but the frontal lobes are relatively spared (Miller et al., 1996; Edwards-Lee et al., 1997). This research is of interest to our understanding of savant-syndrome because the skills of patients with frontotemporal dementia (FTD),
although diverse, share commonalties with savant syndrome. For example, the skills of such persons are also typically rule-based and lacking symbolic content. Further, this is an area of the brain often believed impaired among savants. From his work using event-related brain potentials (ERPs) Birbaumer (1999) suggests that savants operate using the early low-level stages of processing, not the ensuing multisensory comparisons that form part of conscious processing. Evidence is provided for this claim with ERP data from a “human calculator” who shows enhanced low-level processing with less subsequent cortical involvement.

Using repetitive transcranial magnetic stimulation (rTMS) it is possible to produce temporary disruption to function in cortical regions. This technique can produce sustained and spatially selective interruptions of cortical functioning, producing safe “temporary lesions” that allow the study of the contribution of a given cortical region to a specific behaviour (Pascual-Leone et al., 1999). Therefore, as proposed by Snyder and Mitchell (1999), we employed this technique to investigate if disruption to frontotemporal lobe (FTL) cortical function allowed normal participants to access savant-like talents. If, by interfering with higher level functioning in normal participants, we found significant improvements in the talents that mediate savant activities (i.e., perfect pitch, eidetic imagery, visual representation, mathematical skills, reading ability, and memory), support for the hypothesis of Snyder and Mitchell (1999) would be provided.
Method

Participants

Seventeen right-handed participants aged 20–45 years were recruited from the population of suburban Adelaide. The final sample consisted of 8 females and 9 males with a mean age of 34 years (SD ¼ 7.3). Participants all had normal neurological histories. Potential participants were excluded if they had a history of epilepsy, neurosurgical procedure, or cardiac pacemaker, consistent with safety guidelines outlined in Wassermann (1998). All participants received an information sheet outlining risks and gave written informed consent. Although participants were informed about rTMS they remained naïve to the hypotheses of the study. All procedures had ethical approval from the Human Research Ethics Committee of the University of Adelaide and University of South Australia.

Apparatus

The present study measured memory, artistic merit and accuracy, mathematics, pitch, calendrical calculation, and linguistic representation. Memory was measured using subtests from the Wechsler Memory Scale-Third Edition (WMS-III; Wechsler, 1998) and Wechsler Adult Intelligence Scale-Third Edition (WAIS-III; Wechsler, 1997). Specifically, immediate recall (short-term memory), delayed recall (long-term memory), visual recall and digit span (verbal memory) were assessed. To test immediate (short-term) and delayed (long-term) memory participants were given a name, address, and telephone number to remember. They were asked to recall it immediately. After the other 8 psychological tests had been administered (i.e., approximately 12 minutes later) they were asked to recall it again. Three forms of near equal degree of difficulty were designed for this test. Immediate and delayed responses were scored using criteria similar to that employed in the Wechsler scales. One mark was allocated for title, first
name, surname, street number, and so forth. Five items from the Wechsler Memory Scale-Third Edition (WMS-III; 1997) Spatial Span Subtest and ten items from the Wechsler Adult Intelligence Scale-Third Edition (WAIS-III; 1998) Digit Span Subtest were administered to provide information relating to recall of information presented verbally (i.e., Verbal Memory). The fifteen items were randomly allocated to three groups producing three parallel forms. Participants were read a series of digits that they were asked to repeat. Number sequences varied in length from 5–9 digits. Participants were allocated two scores for this variable. First the number of sequences correctly recalled and second the total number of digits recalled. The Rey Osterrieth Test (1944) was used to test Eidetic Memory. A combination of forms 1 and 2 produced a third form of approximately equal difficulty. Participants were shown one of the three diagrams and asked to look at it closely for ten seconds. The diagram was then removed and participants were given one minute to reproduce as much as they could remember. A scoring protocol, with a maximum score of 47, consistent with the manual was used. Ten calendars from 1990–2000 inclusive were chosen to assess calendrical ability. Calendar 6 (i.e., 1993; 1999) is repeated twice during this time span and was therefore eliminated from the test. The other calendars were randomly allocated to three groups. Participants on all three occasions were shown three calendars and asked to identify that calendar year. Response time and accuracy were recorded. The “Pitch Discrimination Subtest” of the Measures of Musical Abilities (Bentley, 1963) was used to test pitch. This test requires participants to discriminate between two sounds and indicate whether the second sound is “up” or “down” from the first or the “same” as the first. Items 11–20 from this scale were used. Items 1–10 were not used in formal testing, as they were considered too easy and unlikely to discriminate between participants. Participants received a score out of ten on this measure.

To measure artistic ability participants were asked to
replicate a drawing of a horse presented to them. The scoring was consistent with the criteria outlined in the Goodenough-Harris Drawing Test Manual (Harris, 1963) which was adapted accordingly. The focus was on replication rather than production. A horse was chosen for participants to draw as typically artistic savants have shown an interest in horses and hooved animals (Selfe, 1977, 1983). Data for this construct were scores out of 47 using scoring criteria similar to those described in the Good-Enough Harris Drawing Test (Harris, 1963). In addition, three local artists, naïve to the design of the study and blinded to the experimental condition in which the drawings were made, ranked each horse from 1–51 (i.e., least to most artistic). They then assigned each horse a mark out of 20 for artistic impression. The former scores were therefore considered to reflect replication accuracy whereas the latter score reflected artistic merit. The interrater reliability coefficient between the three artists, all of whom were naïve to the nature of the study, ranged between .53 and .72 (p < .01). Mean scores from the artists’ impressions were used in subsequent analyses. A one-way ANOVA controlling for condition was conducted to see if one form was significantly more or less difficult. The overall model was non-significant, F (2, 48) = 0.16, p = 0.86, indicating that each form presented with the same degree of difficulty. The reading subtest of the Wide Range Achievement Test-III (WRAT-III; Wilkinson, 1993) was used. The last 24 words on both the blue and tan forms were used and randomly allocated to one of three alternate forms. Participants were asked to read a word list aloud. A score out of 16 was awarded, one mark for each correct response. Two mathematical concepts were used to test mathematical ability: prime numbers and integer calculations, specifically multiplication. For the prime number task three separate grids were constructed. The first contained numbers 300–399, the second 400–499, and the third 500–
Participants were shown a grid and instructed to start at the first number in the first row and work their way across from left to right, one number at a time, one row at a time, circling prime numbers and crossing out composite numbers. Participants were allowed 45 seconds. An error rate was calculated for responses on each form. In addition participants received a score for the number of prime numbers correctly identified, the number of composite numbers correctly identified, and the number of overall attempts made. In the second task, integer calculation, numbers 1–9 were randomly drawn from a hat until a 2 by 2 digit multiplication sum was constructed. This process continued until three groups of five multiplication problems had been established. Participants were asked to complete the five multiplication problems as quickly and as accurately as possible. Response time and accuracy were recorded.

Tests were administered under three different conditions. No stimulation was used during Condition 1. Condition 2 comprised rTMS to the left motor cortex (MC) hand area (approximately 4 cm anterior to, and 7 cm lateral to the vertex). This region was selected because disruption to this area typically manifests in motor difficulties rather than disruption typically observed among savants. Additionally, the MC stimulation condition served as a control for nonspecific arousal effects due to the sensation associated with rTMS. In Condition 3, rTMS was applied to the left frontotemporal cortex (FTL) by stimulating to a point midway between electrode positions F7 and T3 in the International 10/20 electrode placement system. Conditions 1 and 2 served as control conditions with Condition 3 being the experimental condition. The order of condition presentation was randomized and counterbalanced across subjects to reduce the effects of learning, differences between alternate forms of the tasks, order, and practice.

Each testing condition consisted of 3 test blocks lasting 3 minutes. Therefore, in the MC and FTL conditions rTMS was applied at a frequency of 0.9 Hz for the duration of the testing blocks (3 minutes each).
A short break of approximately one minute between blocks allowed the coil to cool. Between conditions there was a five-minute break. The tests were completed in the same order within each condition to counterbalance the effects of learning during conditions. The whole procedure took approximately one hour for each participant. Participants were unaware of Switching skills on by turning off part of the brain.

the hypotheses being tested. Persons blind to the stimulation status of each data set scored the psychological tests.

Repetitive TMS (rTMS) was applied at a stimulation rate of 0.9 Hz with a figure of eight coil. This rate of stimulation was achieved by using 3 Magstim 200 stimulators linked together with two Bistim units (The Magstim Company Ltd, Dyfed, UK). With stimulators linked in this manner each participant’s active motor threshold was determined for the right first dorsal interosseus (FDI) muscle during a minimal (approximately 5% of maximum voluntary contraction) voluntary contraction. Active motor threshold was defined as the minimal stimulus intensity that evoked a mean MEP of 100 mV in 10 consecutive trials. The intensity of stimulation during testing was set at 5% of stimulator output below active motor threshold. The stimulation intensity employed for testing ranged from 33–50% (M = 41.0, SD = 5.1)

5.1). Stimulation sites were marked to ensure reliable and reproducible placement of the stimulating coil. The coil was aligned with the handle pointing posteriorly. This orientation results in the induced current in the cortex flowing in a posterior to anterior direction. To monitor for possible initiation and spread of motor activity, a phenomenon that has been shown to be associated with seizure induction (Wassermann, 1998), electromyographic (EMG) recordings were made from the first dorsal interoseus, forearm extensors and biceps brachii muscles.
using surface electrodes taped over the muscles.

A small pilot study was conducted to determine suitability and reliability of measures and order of task presentation. Test-retest reliability for all measures was considered acceptable. To minimize any differences in test difficulty, alternate forms of each test were randomly allocated to each condition.

Results

Subjects tolerated the testing procedures well and no side effects were reported. Variables measuring artistic ability, visual, delayed and immediate memory and linguistic representation (hyperlexia) were found to be normally distributed and low in skewness and kurtosis. Variables measuring prime number tasks on the whole met multivariate assumptions despite being positively skewed and kurtotic. The error rate for this task did not meet these assumptions but was not transformed because it represented meaningful data in its original form. Variables measuring calendrical calculation ability revealed only one participant correctly identified the dates on all tasks across the three conditions. Consequently, these data could not be used in meaningful multivariate analyses. Variables measuring musical ability, digit span, and mathematical ability violated multivariate analysis assumptions but were not transformed given the sample size and given that in their original form despite being skewed and/or kurtotic represented interpretable data.

Two sets of planned comparisons were conducted. The first compared frontotemporal lobe stimulation (FTLS) against both control groups and FTLS with motor cortex stimulation (MCS). The second exploratory analysis compared NS with

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Table 1. Means and standard deviation for visual recall forms

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<th>Form</th>
<th>N</th>
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the generalised effects of stimulation (i.e., NS with MCS and FTLS). Due to the increased risk of Type 1 errors accompanying multiple planned comparison, a correction was made using the modified Bonferroni test in order to maintain an alpha of .05.

Digit span (verbal memory) was measured according to correct number of sequences and number of digits per sequence correctly recalled. Visual recall (eidetic memory) forms were designed to be parallel forms and reflect similar degrees of difficulty. To ensure that difficulty was not a confounding variable, forms were equally represented in each condition. Table 1 below shows the means and standard deviations for the three alternate forms. A one-way ANOVA controlling for condition was conducted to determine if one form was significantly more or less difficult. The overall model was nonsignificant $F(2, 48) = .16, p = .86$, indicating that each form presented with the same degree of difficulty.

A two-way within subjects repeated measures multivariate analysis of variance (MANOVA) was conducted to test the hypothesis that stimulation applied to the FTL would enhance visual, verbal, and delayed memory (long-term memory), and impair immediate memory (short-term memory). Although no main effect of condition on memory was found $F(1, 16) = 1.44, p = .32$, analysis of effect size using partial eta squared $\eta^2 = .67$ revealed a strong effect, suggesting that had the sample size been larger, increasing power ($1 - \beta = .31$).
statistical significance may have been achieved.

A planned comparison comparing NS with FTLS and MCS with FTLS revealed as predicted a significant deterioration in immediate memory recall when stimulation was applied to the FTL compared to the MC F(1, 16) \( \frac{5.45}{4} \), p < .05, suggesting that immediate recall was worse during stimulation to the FTL. Comparisons between NS and stimulation to the FTL did not reach statistical significance in the direction predicted but a trend towards deterioration in immediate recall performance was observed when stimulation was applied to the FTL F(1, 16) \( \frac{2.52}{4} \), p \( \frac{.07}{4} \). A second exploratory planned comparison comparing the general effects of stimulation (i.e., MCS and FTLS) to NS was nonsignificant, suggesting location was important to this result.

A two-way within subjects repeated measures MANOVA was conducted to test the hypothesis that stimulation applied to the FTL would enhance calendrical calculating ability. Although the overall model was nonsignificant F(1, 16) \( \frac{2.05}{4} \), p \( \frac{.15}{4} \) analysis of effect size using partial eta squared \( \frac{.37}{4} \) revealed a moderate effect, suggesting statistical significance may have been achieved had the sample size been larger thereby increasing power (1 - \( \frac{.46}{4} \)).

A planned comparison comparing NS with FTLS, and MCS with FTLS revealed, as predicted, a significant difference in participant’s ability to correctly calculate calendars when stimulation was applied to the FTL compared to the MCS condition F(1, 16) \( \frac{1}{4} \).
A two-way within subjects repeated measures MANOVA was conducted to test the hypothesis that stimulation applied to the FTL would enhance musical ability. Although overall the model was non-significant, $F(1, 16) = 0.82$, $p = 0.46$, analysis of effect size using partial eta squared $= 0.10$ revealed a weak effect. Observed power was low ($1 - \beta = 0.1$).

A two-way repeated measures MANOVA was conducted to test the hypothesis that stimulation applied to the FTL would enhance artistic ability. The overall model was non-significant, $F(1, 16) = 1.71$, $p = 0.21$, partial eta squared $= 0.48$, indicating a moderate effect. Observed power ($1 - \beta$) = 0.42. Planned comparisons comparing NS with FTLS, MCS with FTLS and NS with both MCS and FTLS revealed no effect of condition upon either representational accuracy or artistic merit.

Data for this linguistic representation were reading scores out of sixteen on the Wide Range Achievement Test (3rd ed.; WRAT-111; Wilkinson, 1993). A two-way repeated measures MANOVA was conducted to test the hypothesis that stimulation applied to the FTL would enhance reading ability. The overall model was non-significant, $F(1, 16) = 0.83$, $p = 0.45$, partial eta squared $= 0.10$, indicated a weak effect. Observed
power was low (1 .

b) ¼

.17. Planned comparisons comparing NS with FTLS, MCS with FTLS, and NS with both MCS and FTLS revealed no effect of condition upon reading ability.

Integer calculation was operationalised by number of correct multiplication calculations (i.e., accuracy) and total response time (i.e., speed).

A two-way repeated measures MANOVA was conducted to test the hypothesis that stimulation applied to the FTL would enhance integer calculation ability. Contrary to expectations, the overall model was nonsignificant F(1, 16) ¼ 1.29, p ¼ .32, partial eta squared ¼ .28 revealed a small effect. Observed power was small (1 .

b ¼ .30).

Data measuring prime numbers were collected by counting the number of prime and composite numbers correctly identified, total number attempted and error rate. A two-way within subjects repeated measures MANOVA was conducted to test the hypothesis that stimulation applied to the FTL would enhance factorization and prime number generation ability. Contrary to expectations, the overall model was non-significant F(1, 16) ¼ 1.15, p ¼ .41. Analysis of effect size using partial eta squared ¼ .51 revealed a moderate effect, suggesting that had the sample size been larger, increasing power (1 .

b ¼ .61
statistical significance may have been achieved.

A significant difference in error rate was, however, found between NS and FTLS conditions $F(1, 16) = 3.70, p < .05$.

A second planned comparison comparing the general effects of stimulation (i.e., MCS and FTLS) with NS revealed a significant effect of stimulation on participant’s ability to generate composite numbers $F(1, 16) = 3.30, p < .05$ (1-tail Sig.), and a reduction in the amount of errors made $F(1, 16) = 3.19, p < .05$ (1-tail Sig.).

As some aspects of testing involved written (motor) responses and others verbal responses, data were checked to determine if a difference in performance involving written versus verbal responses existed. It might be argued that a slight decline in performance should have been observed in written tasks when stimulation was applied to the MC but this was not supported by statistical analysis.

Visual inspection of the data revealed that one participant scored better on all tasks when stimulation was applied to the FTL in contrast to no stimulation, and another participant scored better on all but one task when FTL stimulation was administered. Performance by other participants across conditions was idiosyncratic.

Examination of savant deficits suggests that short-term memory is impaired while declarative and procedural memory appears to be spared. Therefore, if rTMS has the desired effect in the current investigation, deterioration in performance
on tasks measuring short-term memory should be observed when rTMS is applied to the FTL. It is difficult to assess the efficacy of stimulation of nonmotor areas. However, we hypothesized that effective stimulation of the frontotemporal region should lead to deterioration of short term memory function, as this region of the cortex has been shown to play a critical role in short term memory (Miller et al., 1996, 1998).

Closer inspection of the data on a case-by-case basis showed that four had the requisite deteriorated memory (i.e., >1 SD). This was determined by comparing immediate recall in the no stimulation condition with immediate recall when the frontotemporal lobe was stimulated. Analyses of their data show improvement in the predicted direction across all measures with the exception of delayed memory. To address this, a variable was calculated by measuring decline in immediate recall across the two conditions (i.e., NS and FTLS). This variable was considered to reflect deterioration in short-term memory performance. This variable significantly correlated with artistic representation ($r = .47, p < .05$), and reading ($r = .48, p < .05$) using all 17 participants. This demonstrates that the more effective the stimulation was in interfering with short term memory (and FTL function) the better the improvement for the FTL stimulation condition.

Discussion

Overall group comparisons produced modest effects with respect to delayed memory performance that improved during stimulation to both areas of the left hemisphere (MC and FTL), suggesting left hemisphere dysfunction may be sufficient irrespective of locality (Treffert, 2000). This finding might explain why enhanced delayed memory function is consistently reported among most savants and appears to be a minimum requirement for the development of other savant skills (Stevens and Moffitt, 1988; Nettelbeck and Young,
1999). More specialized skills such as music, art, and calend-

Switching skills on by turning off part of the brain 219
crical calculation may, however, require more localised disruption
to functioning of the frontotemporal cortex as these
types of skills were only enhanced during the experimental (FTL) condition. This hypothesis could be tested by employing
a further control stimulation condition consisting of right hemisphere rTMS.

Analyses looking at differences between conditions are
only valid if stimulation led to effective disruption of FTL
function. Despite overall decline in immediate recall, which
we took as a sign of FTL dysfunction, the data would indicate
that not all subjects were similarly affected. The variable
response between subjects may be due to a number of factors
including poorly localized stimulation, and nonoptimized
stimulation intensity or frequency. There were a number of
limitations in the present study on the magnetic stimulation
parameters employed for testing. First, in order to reduce
interference with motor aspects of task performance it was
necessary to use sub motor threshold magnetic stimuli.
Second, to reduce the risk of adverse side effects it was
necessary to keep stimulation intensities as low as possible.
Although the subthreshold stimulus intensity employed in
the present study may not be optimal there is some evidence
that stimulation at intensities of active motor threshold
(Jahanshahi et al., 1998) or below rest (Rossi et al., 2001)
or active motor threshold (Rami et al., 2003) are capable of
disrupting cortical function. Again, the stimulation frequency
employed in the present study may not have been optimal for
disruption of cortical functioning but because of technical
limitations we were unable to use higher frequencies of
stimulation.

Therefore, an analysis of data for individuals in whom there
was evidence of disruption to FTL function is more informative
than looking at group trends.
For example, striking improvements during FTL stimulation were noticed for one participant in his ability to draw a horse that was judged in terms of representational accuracy and artistic merit (see Fig. 1). He was unable to replicate this performance during repeated trials outside of the experimental conditions. This participant also showed the greatest decrement in immediate performance between the nonstimulation condition and the FTL stimulation condition.

Further, 5 out of 17 participants scored better on both measures of calendrical calculation when stimulation was applied to the FTL. These five also showed some degree of decline in immediate recall between the two conditions.

Visual inspection of these data overall revealed that one participant scored better on all tasks when stimulation was applied to the FTL in contrast to no stimulation, and another participant scored better on all but one task when FTL stimulation was administered. Performance by other participant’s across conditions was idiosyncratic.

Further, not all participants improved across all tasks and we can only hypothesize as to why this was the case. The most likely scenario is that either not all individuals have access to these mechanisms or that the stimulation was not equally effective for all participants. There is strong support in these

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Fig. 1. Example from one subject showing performance on artistic representation and accuracy test. (a) No stimulation condition, (b) FTL stimulation, and (c) MCS stimulation. Data for this construct were scores out of 47 on scoring criteria adapted from the Good-Enough Harris Drawing Test (Harris, 1963). It can be clearly seen that performance was better in the FTL stimulation condition (score 35) than in the no-stimulation condition (19). In this subject performance was also improved during MCS stimulation (32) but not to the
same degree as in the FTL stimulation condition. Data for the latter, with only four participants having the requisite deteriorated memory (i.e., >1 SD).

Although the nature of savant memory is not fully understood it is generally accepted that savants demonstrate better declarative memory and/or long-term memory than other aspects of memory. Moreover, research suggests that the type of memory preserved is specific (Nettelbeck and Young, 1999). It is therefore plausible to suggest that preservation of recall after a delay exists in savant brains but FTL damage impairs immediate recall. These results provide evidence for a distinct neuroanatomical substrate responsible for declarative memory. They also support the idea that individuals can demonstrate superior declarative memory juxtaposed with deficits in performance in other areas of memory.

Visual inspection of the data showed that 5 out of 17 participants scored better on both measures of calendrical calculation when stimulation was applied to the FTL. Therefore, through disruption to cortical functioning by artificial (i.e., rTMS) or biological means (i.e., FTL lesions), individuals may be able to access the mechanism(s) that promotes the development of this skill. Research also suggests that the initial acquisition of relevant rules may be dependent on an internal (Treffert, 2000) or external source of knowledge (Nettelbeck and Young, 1999). No participant in this study provided evidence that they were able to access such knowledge as overall performance on this task was poor. This suggests that opportunity and exposure to this knowledge may be pivotal in its development.

In light of the results, it is plausible to suggest that the site of damage may be important to the development of some skills such as prime number identification, factorization and calendrical calculation. This may suggest that despite damage to this area of the cortex some mechanism(s) may be spared that underpins the development of certain skill.
The reasons why some savants have prodigious mathematical abilities remains unclear and why the skill is typically limited to multiplication and factorization is even more mysterious. It may also be that the ability is acquired through the inheritance of a mechanism(s) and/or talent which underpins the development of the skill. However, how the rules required for mathematical calculations are acquired in the first place is unclear as savants are unable to verbalize the method(s) they employ (Nettelbeck and Young, 1999). No participant in this study provided evidence that they were able to access such knowledge and/or mechanism(s).

Overall these data suggest that contrary to Snyder and Mitchell’s hypothesis (1999) these mechanisms are not accessible to everyone and individuals may differ in either their ability to access these mechanisms or even whether they possess such a mechanism(s). It is proposed here that such differences may be due to variables such as hereditability, sex, age, and/or opportunity. These findings also suggest that these skills may be limited to a small percentage of the ‘‘normal’’ population. Nettelbeck and Young (1999) and Young (1995) found that among their savant sample, a disproportionate number of family members had high levels of intelligence and a familial history of skills. This suggests that in order to be able to develop a skill you need to have a genetic predisposition toward the skill. This might explain why all subjects did not demonstrate superior performances when receiving FTLS. Further support for this argument comes from the low frequency of savant abilities among people with neurological impairment in general. If all persons with neurological impairment were able to access these skills one might expect that savant syndrome would be more common.

Although genetic factors may determine the degree and extent of the ability which is passed on, thus enabling some individuals endowed to attain excellence more easily than others, there is also debate over the importance of environmental
influences on savant ability (Treffert, 2000). In some cases savants display levels of mastery that others would never be able to attain, regardless of the amount of practice invested. However, factors such as age, ability to concentrate and obsessive practice, coupled with positive reinforcement from the environment, are all processes thought to underpin the development of excellence among such individuals (Nettelbeck and Young, 1999). It is often documented that what enables savants to develop these skills is their ability to concentrate and obsess over their skill to the detriment of all other thoughts. Like all skills, savant skills are practiced, but may be overwhelmed as more complex thought processes develop (Ericsson and Faivre, 1988; Ericsson et al., 1993).

This controversy over the relative importance of genetic influences on skills and performance is older than psychology itself (Obler and Fein, 1988). The most commonly held view is that genetic factors determine the degree and extent of basic abilities. This means that individuals endowed with greater capacity or specialized capability are able to achieve a specialized level of performance more easily than normal individuals. If the heritability argument is to be tested, research should include participants whose parents have shown precocity in skills typically found among savants (e.g., art, music, and maths).

A noteworthy result from formal testing on gender comparisons on eidetic memory, measuring an artistic replication of a horse and visual recall (measured on the Rey Osterrieth Test), is the fact that males scored better than females in their recall of visual images and were more accurate in their replicated drawing of a horse from memory, when stimulation was applied to an area of the left hemisphere. This is consistent with an overall trend observed in the means for males to perform better than females under stimulation. It may be that males are either more affected by the stimulation or trauma, or that these mechanisms are more apparent and/or accessible to males than females.
The present study was limited technically to employing stimulation rates of approximately 1 Hz. The recent development of a magnetic stimulator capable of delivering stimuli at rates of up to 60 Hz, which may be more efficacious for disrupting cortical function, promises to expand the scope in neuropsychological research of magnetic stimulators. Future research should focus on determining the rate of stimulation that best achieves disruption to higher cortical functioning yet falls within the recommended guidelines.

Further research focussing on the locality of the left hemisphere lesion thought to be responsible for unmasking the skill(s) would enhance our understanding of savant skills. This would be a significant breakthrough in savant syndrome research as the locus of impairment may affect the type of mechanism(s) accessed and thus determine the type of skill that emerges.

It is known that the development of savant skills requires factors such as intense interest and preoccupation, a familial predisposition toward high achievement and reinforcement in addition to a mechanism underpinning these skills (Young, 1995). Therefore, the fact that some skills were shown to improve without the benefit of these factors in the present study is encouraging. Future research should attempt to work with a larger number of participants to improve power and look at the effect of the aforementioned factors.

The results of this research suggest that contrary to Snyder and Mitchell’s (1999) predictions, the demonstration of savant-type skills may be possible for some, not all, individuals just as it appears to be the case in the disabled population.

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Questions
1. Why were only right handed people chosen to participate in the study?
   Savant abilities are usually extremely and intensely creative beyond all normal capabilities. Right handed people are consistently more logical and rational than their left handed counterparts who most times excel in the creative arts. Also, right handers make up a majority of the population, making them the most normal. Thus, right handed people are the most deviated from the typical savant and it would be most remarkable if savant abilities were unlocked in them.

2. Why did the authors include the drawings of the horse?
   The drawings were included so that the readers could see for themselves the improvement in artistic ability after brain stimulation with magnetic impulses. It’s concrete evidence so the readers can see that the authors aren’t exaggerating.

3. Why is it mentioned that among the savant sample, a disproportionate number of family members had high levels of intelligence and a familial history of skills?
   The authors suggest that in order to develop a skill you need to have a genetic predisposition toward the skill. So far, there is no evidence that everyone can develop savant abilities. Further support for this argument comes from the low frequency of savant abilities among people with neurological impairment in general. Savant syndrome would be more common if all people with neurological impairment were able to access such skills.

4. Why do the authors mention that men were better able to recall and redraw the horse from
memory under stimulation?
Savant ability is six times more common in men than women; it is a similar rate for autism. This shows that magnetic pulses are stimulating the same areas as the natural savant stimulation but to lesser extents.
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