

Savant Syndrome: An Extraordinary Condition

A Synopsis: Past, Present, Future

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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 over-arching 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 compo-

nent 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.

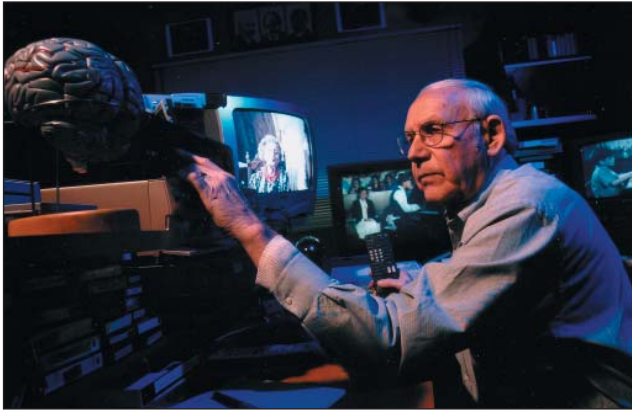
New imaging techniques and other novel research approaches, described herein, provide additional tools to better explore the unique window into the brain that this remarkable condition provides with its vast implications for not only better understanding savant syndrome, but perhaps shedding light as 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.

Introduction

Savant syndrome is a rare, but extraordinary condition in which persons with serious mental disabilities, including autistic disorder, have some “island of genius,” which stands in marked, incongruous contrast to overall handicap. As many as 1 in 10 persons with autistic disorder have such remarkable abilities in varying degrees, although savant syndrome occurs in other developmental disabilities or in other instances of CNS injury or disease as well.¹ Whatever the particular savant skill, it is always linked to massive memory.

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At the 1964 American Psychiatric Association Annual Meeting, the case of the calendar calculating identical twins, both autistic, was presented. These 2 brothers had a calendar-calculating span of over 40,000 years backward and forward. Their other incredible abilities were later described in detail by Sacks, and some of those skills were incorporated into scenes in the movie *Rain Man*.² A discussant of that paper remarked that the importance of the savant lies in our inability to explain him or her, and that the phenomenon of the savant remains a challenge to our capabilities. While there is as yet no over-arching theory that can explain all cases of savant syndrome, more progress has been made in the past 15 years than in the prior 100. Yet, as the discussant remarked, savant syndrome remains a challenge to our capabilities.

Where We Have Been

Savant syndrome, with its “islands of genius,” has a long history. Benjamin Rush provided one of the earliest reports in 1789 when he described the lightning calculating ability of Thomas Fuller, “who could comprehend scarcely anything, either theoretical or practical, more complex than counting.”³ 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 2,210,500,800 in 90 seconds, even correcting for the 17 leap years included. Actually, however, the first description 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.⁴

The now regrettable term idiot savant was coined by Down in 1887 when he presented 10 cases in colorful detail from his 30-year experience at the Earlswood Asylum.⁵ These cases demonstrated the typical musical, artistic, mathematical, and mechanical skills, coupled with phenomenal memory, that have so unfailingly re-

occurred in savant syndrome to the present day. Down meant no harm by that term. At that time “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.” 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, the term “idiot savant” was replaced with “savant syndrome,” which is now widely used. Savant syndrome is preferable to “autistic savant,” since only about 50% of persons with savant syndrome have autistic spectrum disorder, while the other 50% have some other forms of CNS injury or disease.

The first definitive work on savant syndrome was a chapter by Tredgold in his 1914 textbook, *Mental Deficiency*.⁶ In 1978, Hill provided a review of the literature between 1890 and 1978 including 60 reports involving over 100 savants.⁷ 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.⁸ Treffert provided an updated review in 1988, which contained more detail on all of those earlier cases.¹ Since 1988, there have been 6 books on the topic, and several other review articles with extensive bibliographies.⁹

What We Do Know

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

1. The condition is rare but 1 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% incidence of savant syndrome has become the generally accepted figure in autistic disorder.⁸ Hermelin, however, estimates that figure to be as low as “1 or 2 in 200.”¹⁰ The presence of savant syndrome is not limited to autism however. In a survey of an institutionalized population with a diagnosis of mental retardation, the incidence of savant skills was 1:2000 (.06%).¹¹ A more recent study surveyed 583 facilities and found a prevalence rate of 1.4 per 1000, or approximately double the Hill estimate.¹²

Whatever the exact figures, mental retardation and other forms of developmental disability are more common than autistic disorder, so about 50% of persons with savant syndrome have autistic disorder and the other 50% 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.

2. Males outnumber females in autism and savant syndrome

In explaining this finding, Geschwind and Galaburda—in their work on cerebral lateralization—point 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.¹³ In the male fetus particularly, circulating testosterone, which can reach very high levels, can slow growth and impair neuronal function in the more vulnerable exposed left hemisphere, with actual enlargement and shift of dominance favoring 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, as will be explained below. Other conditions, such as dyslexia, delayed speech, and stuttering—also with male predominance in incidence—may be manifestations of this same left hemisphere interference in the pre-natal period.

3. 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 are usually found in 5 general categories:

Music: usually performance, most often piano, with perfect pitch; composing in the absence of performing has been reported, as has playing multiple instruments (as many as 20)

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

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 mapmaking and direction-finding.

Other skills that have been reported less often include prodigious language (polyglot) facility; unusual sensory discrimination in smell, touch, or vision, including synesthesia; perfect appreciation of passing time without benefit of a clock; and outstanding knowledge in specific fields such as neurophysiology, statistics, or naviga-



King's College Choir, Richard Wawro, Edinburgh

tion.¹⁴ In Rimland's 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.⁸

Generally a single special skill exists, but in some instances several skills exist simultaneously. Rimland and Fein noted the incidence of multiple skills appeared to be higher in savants with autism than in savants with other developmental disabilities.¹⁵ 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.

4. 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 probably fewer than 50 prodigious savants known to be living worldwide at the present time who would meet that very high threshold of savant ability.

5. The skills tend to be right hemisphere in type

These skills can be characterized as non-symbolic, artistic, concrete, and directly perceived, in contrast to left

hemisphere skills that are more sequential, logical, and symbolic, including language specialization.

6. The special skills are always accompanied by prodigious memory

Whatever the special abilities, a remarkable memory of a unique and uniform type welds the condition together. Terms such as automatic, mechanical, concrete, and habit-like have been applied to this extraordinary memory. Down used the term “verbal adhesion”;⁵ Critchley used the terms “exultation of memory” or “memory without reckoning”;¹⁶ Tredgold used the term “automatic”;⁶ and Barr characterized his patient with prodigious memory as “an exaggerated form of habit.”¹⁷ Such unconscious memory suggests what Mishkin and Petri referred to as non-conscious “habit” formation rather than a “semantic” memory system.¹⁸ They proposed 2 different neural circuits for these 2 different types of memory: a higher level cortico-limbic 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.

7. Savant syndrome can be congenital, or it can be acquired following brain injury or disease later in infancy, childhood, or adult life

Recent reports of savant-type abilities emerging in previously healthy elderly persons with fronto-temporal dementia are particularly intriguing.^{19,20}

8. Savant skills characteristically continue, rather than disappear, and with continued use, the special abilities either persist at the same level or actually increase

In almost all cases, unlike the case of Nadia, there is no trade-off of special skills with exposure to more traditional schooling.²¹ Instead, the special skills often serve as a conduit toward normalization with an actual improvement in language acquisition, socialization, and daily living skills.

9. No single theory has emerged thus far that can explain all savants

An important, basic question surrounding savant syndrome is: *how do they do it?* Numerous theories have been put forth, but no single, over-arching theory can explain all savants. Those theories have included eidetic imagery (or the related but separate phenomenon generally called photographic memory), inherited skills, sensory deprivation and sensory isolation, highly developed rote memory, and compensation and reinforcement to offset lack of more general capacity or intelligence.¹ There are

problems with each of these theories. For example, 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.^{22,23} Two studies, 1 with 25 savants and another with 51 subjects, showed relatives with special skills in some but certainly not all cases; another study of 23 relatives of carefully studied savants found only 1 family member with special skills.²⁴⁻²⁶ Several investigators have shown that memory alone cannot fully account for savant abilities, particularly calendar calculating and musical skills.^{10,27}

In recent years, several neuropsychological theories have also directly addressed the abundant reports of splinter and savant skills in the autistic population. Weak central coherence theory (WCC) cites a particular cognitive and perception style—focusing on details rather than the whole—as being present in persons with autism, and postulates that such a style of information processing could be an important part of those persons with savant abilities. Not being distracted by more global patterns, the savant can focus on a single item or skill and perfect it.²⁸ Simon Baron-Cohen has advanced the “extreme male brain” theory of autism, which proposes that a proficiency at systematizing and spatial skills—attributes of the male brain—provide a special predilection of males for autism at the expense of empathy and social skills—attributes of the female brain.^{29,30} He particularly notes such special systematizing skills and lack of social abilities and empathizing in persons with Asperger’s Disorder.³¹

However, these newer neuro-psychiatric theories seem more to describe the autistic person, rather than explain him or her, and they do not account for the fact that, with respect to savant syndrome, only 50% of such persons are autistic, and the remainder have other developmental disabilities or other CNS disorders or disease.

New Findings and New Discoveries

Left Brain Injury and Right Brain Compensation

One theory that does provide an increasingly plausible explanation for savant abilities in many cases is left brain injury with right brain compensation. As pointed out above, the skills most often seen in savant syndrome are those associated with right hemisphere as described by Tanguay.³² Rimland also highlighted the simultaneous nature of right brain activity in savants with autism in contrast to the sequential nature of left brain activities generally.³³

In autistic disorder itself, left brain dysfunction, compared to right brain activity, has been demonstrated in a number of studies. Even before CT scans

and MRI studies were available, and as early as 1975, pneumoencephalograms demonstrated left hemisphere abnormalities (particularly in the temporal lobe areas) in 15 of 17 patients with autism, 4 of whom had savant skills. Investigators in this study concluded that motor and language functions were “taken over” by the right hemisphere because of deficits in the left hemisphere.³⁴ A 1999 PET study showed low serotonin synthesis in the left hemisphere of persons with autistic disorder and other studies have confirmed such left hemisphere deficits as well.³⁵ Boddaert and coworkers demonstrated in 5 children with autism and 8 controls that at rest and listening to speech-like sounds, the volume of activation was greater on the right side and diminished on the left among children with autism; the reverse pattern was found in the control group.³⁶ Escalante and colleagues demonstrated an atypical pattern of cerebral dominance among individuals with autism and a history of early language disorder when compared to both healthy participants and individuals with autism and persons with normal acquisition of early language skills.³⁷

With respect to savant syndrome, in 1980 Brink presented a case of a typically developing 9-year-old boy who was left mute, deaf and paralyzed by a gunshot wound to the left hemisphere.³⁸ Following that injury, unusual savant mechanical skill emerged, presumably from the undamaged right hemisphere. Subsequent reports have likewise implicated left hemisphere injury, such as those in a musical savant and a mathematical savant, and left hemisphere damage documented in both on neuropsychological tests and neuro-imaging studies.^{39,40} Likewise, CT scans and neuropsychological test results for a prodigious musical savant described by Treffert showed left brain damage.¹ Munoz-Yunta and coworkers report similar findings of left hemisphere damage and dysfunction in savant syndrome based on PET and magnetoencephalography techniques.⁴¹

A Significant New Discovery: The “Acquired” Savant

The most powerful confirmation of the left brain dysfunction/right brain compensation theory in savant syndrome, however, comes from a 1998 report by Miller and coworkers who described 5 previously nondisabled patients with frontotemporal dementia (FTD) who acquired new artistic skills with the onset and progression of FTD.¹⁹ Several of these individuals had no previous history of particular artistic abilities, yet prodigious art skills emerged as the dementia proceeded. Consistent with characteristics and traits of savants, the modality of skill expression in these 5 older adults was visual, not verbal; the images were meticulous copies that lacked abstract or symbolic qualities; episodic memory was

preserved but semantic memory was devastated; and there was intense, obsessive preoccupation with the artwork. Neuroimaging studies showed dominant (left) hemisphere injury and dysfunction.

The authors hypothesized that selective degeneration of the (particularly left) anterior temporal and orbito-frontal cortices decreased inhibition of visual systems involved with perception, thereby enhancing artistic interest and abilities. Kapur called this process “paradoxical functional facilitation” and speculated that this process accounts for unexpected behavioral improvement in discrete domains following brain injury.⁴²

In an expansion of that work, Miller described 7 additional FTD patients who acquired new visual or musical talents despite the progression of their dementia.²⁰ The 12 FTD patients with these newly emerged savant-type talents were compared on SPECT imaging and neuropsychological testing to FTD patients without such talent. Nine of the 12 showed asymmetric left-sided SPECT deficits; 1 demonstrated bilateral abnormalities (left on MRI, right on SPECT), and 2 (1 of whom was left handed) had asymmetric right-sided dysfunction. The talented group performed better on tasks assessing right frontal lobe functions, but worse on verbal abilities. The authors conclude: “Loss of function in the left anterior temporal lobe may lead to the ‘paradoxical functional facilitation’ of artistic and musical skills. Patients with the left-sided temporal lobe variant of FTD offer an unexpected window into the neurological mediation of visual and musical talent.”

These FTD cases are interesting additions to the earlier cases of newly “acquired” savant abilities, such as Brink’s case following a gunshot wound to the left hemisphere.³⁸ An internationally known, now-adult savant sculptor had his remarkable talent emerge following a childhood fall.¹ Lythgoe and coworkers describe a 51-year-old male whose prolific drawing and sculpting skills unexpectedly emerged following a subarachnoid hemorrhage that affected principally frontal areas.⁴³

SPECT Imaging in A 9-Year-Old Artistic Savant with Autism

After finding left hemisphere dysfunction (particularly left anterior temporal dysfunction) in the 12 patients with fronto-temporal dementia, Miller and coworkers performed neuropsychological and neuroimaging studies on a newly diagnosed 9-year-old artistic savant with autism.⁴⁴ This childhood artistic autistic savant showed “striking parallels” to other artistic savants, particularly Nadia, with an obsession for 1 art medium (felt-tipped pen), 1 type of subject (cartoon figures), and with extraordinary drawing skills and exceptional visual memory. MRI scan was



Cows, Alonzo Clemens

normal. SPECT showed bilateral increased frontal perfusion with bilateral anterior temporal lobe hypo perfusion, which was worse on the left than on the right. This is the same site of dysfunction noted in the 12 elderly FTD patients with savant-type skills. These researchers concluded: “The anatomic substrate for the savant syndrome may involve loss of function in the left temporal lobe with enhanced function of the posterior cortex.”

A Gene for Savant Syndrome?

In the search for sub-groups within the aggregate autism spectrum disorders, Nurmi and colleagues identified (among 94 multiplex families) 21 families as “savant skills positive” and 73 families as “savant skill negative.”⁴⁵ The subset study of savant-skills positive families yielded significantly increased evidence for linkage to 15q11-q13 compared to savant-skills negative families. Interestingly, the presence of savant skills was the only factor that isolated the subgroup from the larger autistic spectrum disorders group. The authors note that Prader-Willi syndrome is due to a deletion on this same region of chromosome 15 (i.e. 15q11-13) and that some features (puzzle skills, for example) of PWS and autism overlap. The re-

searchers conclude that it is possible that a gene, or genes, in the chromosome 15q11-13 region, “when perturbed contributes to predisposition to a particular cognitive style or pattern on intellectual impairments and relative strengths. Precisely how those skills are manifested in a given individual may be influenced by a variety of environmental, and possibly, genetic factors.”

Prodigies and Savant Syndrome

There is emerging evidence that prodigies and savants may share certain underlying mental processes when carrying out their specialized, expert tasks. Event-related potentials (ERPs) can measure very early components of brain activity reflecting initial, “pre-conscious” stages of mental processing. This fast, low-level preconscious mental activity contrasts sharply with that seen when higher level “executive” functions are accessed during typical information processing. Birbaumer compared ERPs of a “human calculator”—a non-autistic arithmetic whiz—to healthy controls who were the same age, and IQ.⁴⁶ Compared to controls, early on in the calculating process, the expert calculator showed evidence of “enhanced automatic low-level processing.”

Studies are now underway with autistic savant calculators to see whether this particular type of early lower-level processing (“without reckoning”) is the same as that used by the non-autistic “expert” calculator.

In a similar effort using PET, Pesenti and his team examined differences between a calculating prodigy and normal control subjects in the neural basis of mental calculations.⁴⁷ When completing less-complex calculations in a typical manner, both the expert and non-expert persons showed activation in the brain bilaterally but with a clear left-sided predominance for select regions. However when the expert completed complex calculations much more accurately and swiftly than the controls, he “recruited” a system of brain areas implicated in episodic memory including right medial frontal and parahippocampal areas. Moreover, the expert utilized a unique method of exploiting the seemingly unlimited storage capacity of long-term memory in order to maintain the sequence of steps and intermediate results needed for the more complex calculations. On the other hand, the normal control group relied on the more limited span working memory system. Therefore, the expert utilized unique brain mechanisms when demonstrating this special skill. And when performing these special skills, the prodigy is perhaps relying on some right brain capacities and some special memory recruitment, as may be the case for the savant.

An article by Kalbfleisch further explores the functional neural anatomy of exceptional talent and the interfaces between talent, intelligence and creativity in prodigies and savants.⁴⁸

Repetitive Transcranial Magnetic Stimulation (rTMS)

Several investigators are exploring the use of rTMS to temporarily immobilize portions of left hemisphere function to see if—given Miller’s work and some of the other left sided findings summarized above—savant-like abilities emerge in healthy volunteers.

Snyder and Mitchell argue that savant brain processes occur in each of us but are overwhelmed by more sophisticated conceptual cognition.⁴⁹ They conclude that autistic savants “have privileged access to lower levels of information not normally available through introspection.” Snyder and coworkers tested that hypothesis in 11 male volunteers using rTMS applied to the left fronto-temporal region while carrying out 2 drawing tests and 2 proofreading tests.⁵⁰ rTMS did not lead to any systematic improvement in naturalistic drawing ability but it did lead to “a major change in the schema or convention of the drawings of 4 of the 11 participants.” Two of the participants noted improvement in their ability to

proofread and recognize duplicated words. In a similar study, Young and colleagues, using a wide variety of standard psychological tests and tasks specifically designed to test savant skills and abilities, showed that savant-type skills improved in 5 out of 17 participants during rTMS stimulation.⁵¹ They concluded that savant-type skill expressions may be possible for some, not all, individuals, just as it appears to be in the disabled population. This group intends to carry out further studies using more efficacious and targeted stimulation.

These new studies suggest that savant syndrome may be due, at least in part, to “paradoxical functional facilitation” of the right hemisphere allowing for new skills as a compensatory process. Increasingly, however, an alternative theory has been advanced wherein these right brain skills are not necessarily newly developed but instead represent latent but dormant skills that are released from the “tyranny of the left hemisphere,” or, more simply, left cerebral dominance in most persons.

Savants: Past and Present

Dr. Down’s Original 10 Cases of Savant Syndrome

In his 1887 Lettsomian Lectures before the Medical Society of London, Down presented 10 cases encountered in his 30 years in practice that had particularly caught his attention.⁵ Each of these were individuals who, while mentally retarded, exhibited remarkable “special faculties.” Down did not identify any of these special persons as autistic; that designation did not occur until Kanner’s paper over 50 years later.⁵² But in closely reviewing Down’s entire lecture series, he did, interestingly, specifically mention a group of individuals who differed in many ways from those with more typical mental retardation, a group he identified as “developmental” in origin. That term—developmental disability—is now applied to autistic persons a century after Down’s observations. Down’s astute observations regarding this group of “developmental” cases is described in detail on the savant syndrome Web site at www.savantsyndrome.com in the articles section under the title of “Dr. J. Langdon Down and ‘Developmental’ Disorders.”

Down’s description of his 10 cases of “special faculties” in those 1887 lectures reads like descriptions of many savants over a century later. Each of his cases of developmental disability demonstrated some special skills combined with prodigious memory. That is savant syndrome. One of his patients, for example, had memorized verbatim *The Rise and Fall of the Roman Empire*. Other children drew with remarkable skill “but had a comparative blank in all the other higher faculties of mind.” Still other children remembered dates and past



Ping Lian Yeak

events. Arithmetical genius was evident in some children, including lightning calculating. Music and musical memory was also described among the special abilities. And there was yet another boy who was unable to use a clock or tell time in any conventional manner yet had perfect appreciation of past or passing time.

While not identified as such, in reading Down's careful and colorful accounts of his cases of "special faculties," it is clear that among them were some children with what would now be identified as autistic disorder, in which savant syndrome occurs with a distinctive frequency as noted above. Among his cases are the typical artistic, musical, mathematical, and other abilities also so distinctively present in the cases throughout the literature 118 years since Down's original observations.

Later Cases, Including Those of Dr. Leo Kanner

Tredgold presented 20 additional cases 27 years later.⁶ His cases are a catalog of the categories and skills—musical, artistic, mechanical, calendrical, and mechanical/spatial—which are repeated, strikingly so, in all the subsequent cases to date.

The several hundred cases in the literature since Tredgold are summarized in the 1988 review article.⁵³ The 2000 edition of *Extraordinary People: Understanding Savant Syndrome* added additional cases.¹ And the Web site www.savantsyndrome.com has added many new cases worldwide as well.

Six of Kanner's original cases of Early Infantile Autism had specific musical abilities, and Kanner was struck by the overall heightened memory capacity of all 10 of these individuals.⁵² The identical twin calendar calculators first described by Horwitz have been extensively studied since that time.⁵⁴ The brothers have a calendar-calculating range of 40,000 years and they also remember the weather for each day of their adult life. Their ability to compute 20 digit prime numbers, with the inability to do simple arithmetic, as well as some other special abilities were described further by Sacks and were incorporated into some scenes in *Rain Man*.¹

Some Well-known Savants

Without a doubt, the best-known autistic savant is a fictional one: Raymond Babbitt, as portrayed by Dustin Hoffman in the Academy Award-winning® movie *Rain Man*. The original inspiration for the savant portrayed in *Rain Man* was a now 53-year-old male who has memorized over 8600 books and has encyclopedic knowledge of geography, music, literature, history, sports, and 9 other areas of expertise.^{55,56} 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 1 page with the left eye, the other page with the right. An MRI shows absence of the corpus callosum along with substantial other CNS damage. His history and savant abilities are described in detail on the savant Web site.

The phenomenal drawing ability of a British savant with autism has resulted in several popular art books by published by him.^{57,58} His extraordinary memory is illustrated in a documentary film clip, when, after a 12-minute helicopter ride over London, he completes, in 3 hours, an impeccably accurate sketch that encompasses 4 square miles, 12 major landmarks and 200 other buildings all drawn to scale and perspective. A rather marked musical ability has surprisingly surfaced in this artist as well.⁵⁹ Recently, artwork by an eleven year old from the United States has gained international attention.⁶⁰

The triad of blindness, autism, and musical genius continues to be conspicuously over-represented and prominent throughout the history of savant syndrome, including Blind Tom at the time of the civil war, Tredgold's case at the Salpêtrière, and several well known present day musical savants.^{1,61} A Japanese musical savant's ability as a composer demonstrates decisively that savants can be creative; his 40 original pieces

on 2 internationally popular CDs forcefully document that ability.⁶² Smith describes in detail a remarkable language (polyglot) savant in *The Mind of the Savant*.⁶³

Female savants, however, continue to be few. Selfe described the case of Nadia, which has triggered considerable debate about the possible “trade-off” of special skills for language and social skills acquisition.²¹ Viscott documented in detail, including psychodynamic formulations, a female musical savant whom he followed for many years.⁶⁴ Treffert 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.¹

Most reports continue to be anecdotal, single cases. However Young traveled to a number of countries and met with 51 savants and their families, completing the largest study to date on savants, using uniform history taking and standardized psychological testing.²⁵ Forty-one savants carried a diagnosis of autism and the remainder some other type of intellectual disability. Twenty 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 familial predisposition toward high achievement; and a climate of support, encouragement, and reinforcement from families, case workers, teachers, caretakers, and others.

In a recent summary of work with savants, Nettlebeck and Young conclude that rote memory does not provide sufficient basis for savant skills; instead such savant skills are based on extensive, rule-based knowledge confined to narrowly defined abilities, imitative and inflexible.²⁷ They conclude that savant skills do not represent separate forms of intelligences (outside the concept of overall intelligence) and that these skills depend on modular processing and memory structures that have been spared damage affecting other areas of the brain.

Rain Man the Movie/Rain Man Real Life

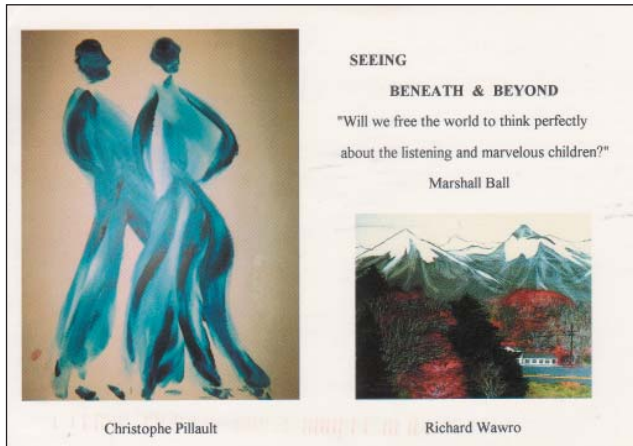
Raymond Babbitt, the main character in the movie *Rain Man*, has become the world’s best-known savant due to Dustin Hoffman’s remarkably accurate and sensitive portrayal of savant syndrome in the film. That 1988 movie, in its first 101 days, accomplished more toward bringing

savant syndrome to public attention than all the efforts in the 101 years following Dr. Down’s 1887 description of the disorder. The movie won 4 academy awards, including Best Picture and Best Actor. A detailed description of the background and chronology of the movie, including those persons Dustin Hoffman studied with in preparation for his role, is contained in a separate chapter in *Extraordinary People*¹ and is described on the savant Web site as well. But several things warrant mention here.

First, the movie is not a documentary. Yet its adherence to credibility and accuracy created an informative and entertaining film. Second, one indicator of that accuracy is that there was no 6-day, cross country “cure” of autism. Instead, the real change in the characters on that 6-day journey occurred in the brother, Charlie, not in Raymond, conveying the important message that in dealing with persons with disabilities it often we who need to accommodate to their needs and specialness, rather than always requiring them to make all the changes if they expect to live side-by-side with us in our communities. Third, as a gentle caveat, the audience needs to realize that Raymond Babbitt is a high-functioning autistic person, and not all autistic persons function at that high level; it is a spectrum disorder. And fourth, as a second caveat, the audience needs to realize as well that not all autistic persons are savants, and not all savants have autistic disorder.

The major message in the movie—the specialness of the autistic savant—is a welcome and positive one. It raised public interest in both autism and savant syndrome. Few disabilities will ever experience the kind of massive public awareness and visibility in such an empathic, uniformly well received, and popular format as *Rain Man* provided autism and savant syndrome.

“Training The Talent”: Successful Education Approaches Etiologic 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?”⁶⁵ Experience has given the answer—train the talent and some of the “defect” subsides. The special talent, in fact, becomes a conduit toward 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 the 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 channeling those abilities more usefully.



Selected artwork by savants Christophe Pillault and Richard Wawro

Clark 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.⁶⁶ This special curriculum proved highly successful in the functional application of savant skills and an overall reduction in the level of autistic behaviors in many subjects. Improvements in behavior, social skills, and academic self-efficacy were reported, along with gain in the communication skills of some subjects.

Donnelly and Altman note that increasing numbers of “gifted students with autism” are now being included in gifted and talented classrooms with non-disabled gifted peers.⁶⁷ Along with such inclusion, they outline some of the other special approaches that are effective with the gifted student with autism, including an adult mentor in the field of their talent, individual counseling, and small group social skills training.

Some specialized schools are emerging as well. For example, Soundscape Centre in London recently began operating 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.⁶⁸ Orion Academy (www.orionacademy.org) in Moraga, Calif, 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.

The Savant Academy (www.savantacademy.org) in Los Angeles, Calif, was established in 2003 specifically to support the education of people with savant syndrome, including linguistic, mathematical, musical, and artistic savants. David Mehnert, himself a musician and teacher, who established the Savant Academy, suggests specialized techniques to unlock hidden savant abilities, using music particularly as a pathway to special abilities. On the Web site, Mr. Mehnert provides more information about those techniques, and also provides some useful information about “myths” surrounding savant syndrome and useful information about perfect pitch, which is an extremely important consideration when dealing with musical savants. More information about perfect pitch and teaching musical savants is also contained in a booklet by Susan Rancer, a Registered Music Therapist.⁶⁹

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* and *Translating with Animals*.^{70,71} She is also autistic. Her recent book, with Kate Duffy, *Developing Talents: Careers for Individuals with Asperger Syndrome and High-Functioning Autism* is an excellent, practical resource for discovering, nurturing, and “training the talent” so that many persons on the autistic spectrum can experience the important experience of work and “the satisfaction of contributing to their families and their communities, of being independent and economically self-sufficient.”⁷² 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, counselors, and others better understand and develop the career planning process for these special persons with special skills.

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 toward explaining this jarring juxtaposition of ability and disability, but many unanswered questions remain. But 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. Images of brain structure are now integrated with studies of brain function using PET, SPECT, and fMRI. Diffusion tensor imaging (DTI) and direct fiber tracking now permit noninvasive tracking of white matter pathways within and between brain regions, better delineating the underconnectivity and overconnectivity problems that are perhaps causal in autism and savant syndrome itself.⁷³ Findings from all these newer techniques can then be correlated with detailed neuropsychological testing in larger samples of savants, comparing and contrasting those findings with data from both impaired and nonimpaired control groups, including prodigies. The interface between genius, prodigies, and savants is especially intriguing, and these 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. Important information from studies already completed has emerged regarding brain function, brain plasticity, CNS compensation, recruitment, and repair.

But there is more to savant syndrome than genes, circuitry, and the brain's marvelous 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 is also comprised of, and 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.

Savant syndrome remains a "challenge to our capabilities," as one discussant described it in an American Psychiatric Association paper in 1964, concluding that the real significance of savant syndrome lies in our inability to explain it.⁵⁴ But savant syndrome is less now a "landmark to our ignorance" than at that APA meeting 41 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. And that important inquiry continues, with the prospect of propelling us along further than we have ever been in unraveling the mystery of these extraordinary people and their remarkable abilities, and in that process, learning more about ourselves and our hidden potential, and possibilities, as well.

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