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Chapter 9

Mnesic Imbalance or Hyperthymestic Syndrome as Cause of Autism Symptoms in Shereshevskii

Miguel Ángel Romero-Munguía

Additional information is available at the end of the chapter

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1. Introduction

Solomon Veniaminovich Shereshevskii (1886-1958) was a man studied by psychologist Aleksandr Romanovich Luria, who thought that Shereshevskii's (S) remarkable memory caused a psychological syndrome with cognitive deficits; consequently, Luria not only described S's memory, but also other aspects of his life such as his synaesthesia, mental imagery, preferences, strengths, weaknesses and personality [1]. Likewise, more recently the phrase "hyperthymestic syndrome" (hyperthymesia) has been coined in order to describe the case of a woman (AJ) whose autobiographical memory is extraordinary, but she has said "it is a burden" [2]. On the other hand, Kanner's clinical description of autistic disorder suggested that excellent rote memory might be involved in its aetiology [3]. In addition, some authors have thought that S could have had an Autism Spectrum Disorder (ASD) [4,5]. So the question arises: if S could have had an ASD, then how might his memory have given rise to such an ASD? For this reason, the present chapter begins by reviewing the evidence for the diagnosis of autistic disorder in S using criteria from the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-IV-TR) of the American Psychiatric Association [6] and from proposed criteria for its fifth edition [7], the chapter also compares his symptoms with those from a famous case (DT) with Asperger syndrome [8,9]. It is concluded that S most likely had autistic disorder. Next, I reviewed the literature to determine whether the assumption that a superior memory may be the cause of autism symptoms would be acceptable or not. However, the data seem to show that S's job as a professional mnemonist was associated instead with a gradual decrease in the severity of some of his autism symptoms [1], notwithstanding, there are great mnemonists without ASD [10,11]. Finally, an alternative explanation regarding the possible relationship between superior memories and au-

tism spectrum disorders is given by the mnesic imbalance theory, which posits that a faulty procedural memory is replaced, in some of its functions, by a relatively preserved declarative memory, resulting in all three diagnostic symptoms of autism [12].

2. Diagnosis of autism spectrum disorder in Shereshevskii

2.1. Diagnostic criteria for autistic disorder by the DSM-IV-TR

Autistic disorder is the most clinically representative of the ASDs [13]. Currently its diagnosis is based entirely on the observation of behaviors listed in the DSM-IV-TR diagnostic criteria [6]. Such criteria can be assessed by the Autism Diagnostic Interview-Revised (ADI-R), which is conducted with the caregivers of individuals suspected of having autistic disorder or other ASD [14]. Consequently, if one wants to make a retrospective diagnosis of ASD in historical figures, then one might use the ADI-R, although it does not cover all ASDs, on biographical texts. However, there are several difficulties in implementing this strategy. First, since the biographical texts are not usually oriented to describe symptoms of psychiatric disorders, possibly such symptoms were not mentioned even though they had been present. Second, some behaviors from historical figures have been considered autism symptoms [15-17], but this attitude has been questioned because of doubts regarding whether the socio-cultural context was taken into account [18]. Third, it is necessary to find the motivation behind behaviors in order to determine whether they are autism symptoms or not [19].

Fortunately, although the psychologist who wrote the psychobiographical text to be discussed in the present chapter did not specifically search for autism symptoms, he pointed out several of these symptoms in S. This historical figure lived in the twentieth century, hence, his socio-cultural context was relatively similar to ours; the motivation behind behavior from S were examined in detail by the author of that text [1]. In addition, there are three major cognitive theories that attempt to explain autism: mentalizing deficit, that is, deficit to infer mental states [20]; weak central coherence, which is defined as disability to see the overall picture but with ability to see details [21]; and finally, executive dysfunction, which is the disturbed activity of the mental processes which control actions [22], although there is a newer version of the first of them called empathizing-systemizing theory which surmises that autism may be explained by a hyper-developed drive to analyze or construct systems (systemizing) with a hypo-developed drive to infer mental states and to react to them with appropriate emotions (empathizing) [23]. Thus, the presence of the cognitive deficits predicted by such theories may be considered motivations associated with autism. Finally, in the present work, the DSM-IV-TR diagnostic criteria will be mentioned in the order in which they appear in that manual diagnostic [6]; every area of the core triad of impairments (social interaction, communicative capacity and behavioral flexibility) is discussed in order to establish whether S had autistic disorder.

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2.1.1. Impairment in social interaction

A total of six (or more) items from criterion A (core triad) are required for the diagnosis of autistic disorder, with at least two from subcriterion A1 (social interaction), and one each from subcriteria A2 (communicative capacity) and A3 (behavioral flexibility), while each of the three subcriteria contains four items [6]. On the other hand, S had impairment in the use of nonverbal behaviors to regulate social interaction (item A1a). Since the biography of S explicitly describes that some individuals always called him *kalter nefesh*, which is a phrase in Yiddish that means *cold soul*, because for instance, he reacted cold-bloodedly to news that other people said to him, so if someone said "Fire!" S did not understand that something was being consumed by flames and consequently he did not show emotions. In this example, the impairment seems secondary to weak central coherence [21].

Besides, S had failure to develop peer relationships (item A1b), which was manifested in various ways. For instance, he had a very good wife and a very intelligent son, but S perceived them as through a haze; also he had difficulties understanding why his fellow men wanted to have any job, which seems to be in accordance with hypo-developed empathizing [23].

Moreover, S showed a lack of socio-emotional reciprocity (item A1d), if his host asked him "How do you like these cigarettes?" he answered "So-so, fair... ", that is, S did not respond reciprocally to the kindness of others, which he explained as secondary to his inability to automatically react appropriately because he neeeded to monitor all his own actions consciously [1]. It might be explained as a sort of self-consciousness disturbance through mentalizing deficit [24] but it might also be explained more directly as secondary to hypo-developed empathizing [23].

In conclusion, the data suggest that S met three of the four items from subcriterion A1, since, unfortunately, the psychobiographical text does not provide enough data to make inferences about item A1c: lack of shared enjoyment [1,6,14].

2.1.2. Impairment in communicative capacity

The biography of S shows evidence that he met item A2b (impairment to initiate or sustain conversational interchange), as only about the time S was over fifty years of age did he learn to follow a conversation and stick to the subject; moreover, S had marked difficulty understanding abstract concepts because he understood only what he could visualize and, therefore, he did not understand phrases such as "to weigh one's words" or "the pressure is higher" [1]. This difficulty with abstract thinking (verbal) along with a higher tendency to use visual mental representations seems most easily explained by the mnesic imbalance theory [12] than by the three major cognitive theories, but also such a cognitive profile has been extensively described by the thinking in pictures hypothesis [25,26]. Both theorical proposals will later be explained in detail.

On the other hand, S also met item A2c (stereotyped, repetitive or idiosyncratic language), since he at least utilized some words that can be described as neologisms for the ADI-R [14]. For example, S used the word *zhuk* (Russian: *beetle*) when he meant *chipped part*, *black bread*,

darkness and *negligence*, whereas to him the word *gis* (Yiddish: *to spill*) assumed the meanings of *sleeve* and *the reflection of a face in the polished surface of the samovar* [1]. This is similar to the phrases *bread basket* instead of *home bakery, fifty five* instead of *grandmother, Annette and Cecile* in order to say *red and blue,* as well as the words *Blum* instead of *a teller of truth* and *hexagon* instead of *six*, all which were spoken by children described by Leo Kanner, who has always been considered as the first to clinically describe autistic disorder [3,27]. However, a recent communication has suggested instead that Hans Asperger could have done so five years earlier [28]. Furthermore, the pronominal reversal shown by S was not so typical of autistic disorder, since he did refer to himself as "he" but did not show echolalia [1,14]. However, his pronominal reversal seems to be related to self-consciousness disturbance shown by individuals with ASD [24].

In summary, there is evidence that S met items A2b and A2c, that is, two of the four items from subcriterion A2, however, there are no data to establish whether S had a delay in spoken language with failure to compensate through gestures (item A2a), not to say that he had a lack of varied and spontaneous social imitative or make-believe play (item A2d) [6], though S always had problems with his ability to distinguish between his visual mental representations and the true word [1]; it is difficult, if not impossible, to develop make-believe play without such an ability.

2.1.3. Impairment in behavioral flexibility

S had an encompassing preoccupation with an interest that was abnormal in intensity and focus (item A3a), specifically, on very detailed and specific visual mental representations. This unusual and circumscribed interest began in S's early years, for instance, when he was five years old he met a *rebe* (Yiddish: *teacher*) but S thought there was a mistake, since that *rebe* in his visual mental representation was something *white*, whereas the *teacher* was a *swarthy* man. Furthermore, his preoccupation on visual mental representations took up most of his time, for instance, when S read this sentence: "N was leaning up against a tree..." he saw N (as a slim young man) standing near a big linden tree with grass and woods all around... But then S continued reading: "and was peering into a into a shop window" then he understood that N was not in a woods but on the street; as a result, S needed to completely rebuild his visual mental representation. Moreover, S was very anxious if he listened to words but their very detailed images did not appear in his mind, for instance, with the word *restaurant* S needed to see "its entrance, people sitting inside, a Romanian orchestra tuning up, and a lot else", while with the word *airport* a S would have seen all details such as the crowd and the police cordon. Also, he did not admit that the words *Mariya*, *Masha*, *Marusya* and *Mary* (Russian variants of the same name) could all apply to the same woman because each word would elicit visual mental representations, which were very distinct one from the other [1,6,14].

Apparently he showed an inflexible adherence to nonfunctional routines (item A3b). For example, if S had to remember the phrase *American Indian*, then he needed to see a very long rope across the ocean from a Russian street to America; these mental journeys were made by him despite the fact that they made him feel exhausted, not by the amount of

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data stored, but because S felt like he really had done those long journeys. Another time he was asked to memorize a table whose numbers were arranged in a simple logical order: 1 2 3 4 – 2 3 4 5 – 3 4 5 6 – 4 5 6 7 – etc. Then S produced visual mental representations in which the number six could be represented by a man with a swollen foot and the number seven by a man with a mustache. Later S remarked that if he had been asked to memorize the letters of the alphabet arranged in a similar order, then he would have proceeded with it in the same way because he would not have noticed such an arrangement [1]. Thus, the first example may be explained by executive dysfunction [22], whereas the second may be explained by weak central coherence [21]. On the other hand, his need of adherence to routines was not limited to his job as a professional mnemonist, for instance, when S participated in a lawsuit for which he practiced imagining the judge's table on the right, he entered the courtroom but the judge was sitting on the left, thus, S lost his head and the case. The latter example may be explained by the mnesic imbalance theory [12,29], which will be explained later.

Besides, S had a persistent preoccupation with parts of objects (item A3d) [6]. For instance, although his synesthesia was present since childhood, even in adulthood he kept showing much preoccupation because of the sensory experiences resulting from it. Thus, even when S was talking with famous people, he would be so interested in their voices that he could not follow what they said [1].

It can be concluded that S met items A3a, A3b and A3d from subcriterion A3, however, there is insufficient information to determine whether S had stereotyped and repetitive motor mannerisms (item A3c). So, one can claim that S fulfilled all the items required by criterion A for the diagnosis of autistic disorder, such as is summarized in Table 1, although we cannot claim that S has had delays or abnormal functioning in social interaction, language or imaginative play prior to age 3 years (criterion B), but it appears that he accomplished criterion C, in other words, he suffered neither Rett's disorder nor childhood disintegrative disorder [1,6].

Core triad	item a	item b	item c	item d	total
1. Social interaction	+	+	-	+	3
2. Communicative capacity	-	+	+	-	2
3. Behavioral flexibility	+	+	-	+	3

Table 1. Items from the triad of core symptoms for diagnosing autistic disorder: Each addition symbol (+) represents an item met by Shereshevskii, whereas each subtraction symbol (-) represents an item for which there is insufficient information to reach conclusions about it.

2.2. Proposed diagnostic criteria for autistic disorder in DSM-V

Currently the DSM-IV-TR guides the diagnosis of ASD [6], but soon its fifth edition (DSM-V) will replace it [7]. For this new edition of the manual, the term Autism Spectrum Disorders (ASD) is proposed instead of Pervasive Developmental Disorders

(PDDs), which includes Rett's disorder, childhood disintegrative disorder, Asperger's disorder and Pervasive Developmental Disorder Not Otherwise Specified (PDD-NOS) [6], however, according to the American Psychiatric Association (APA) the term ASD excludes Rett's disorder [7], although in a previous use of the term ASD also excludes childhood disintegrative disorder [30]. On the other hand, the APA also proposes to stop using these diagnostic categories and use the name ASD as a single diagnostic category [7]. This proposal is based on the lack of reliability of the clinical distinctions among disorders [31], which is in accordance with the rejection of the assumption of normal early language development in Asperger's disorder [32]. So, it has been suggested to continue the use of the DSM-IV-TR and to regard all the PDDs, with the exception of Rett's disorder, as ASD [33]. However, a study found that only 25% of those diagnosed by DSM-IV-TR with Asperger's disorder, 28% of those with Pervasive Developmental Disorder Not Otherwise Specified (PDD-NOS) and 76% of those with autistic disorder met the proposed DSM-V criteria for ASD [34]. This supports the view that the PDD-NOS should not be considered ASD because its diagnosis does not require compliance with the complete diagnostic triad of autism [35]. At first glance, one can assume that it is quite feasible that if the proposed criteria require two symptoms instead of one on impairment in behavioral flexibility (restricted, repetitive patterns of behavior, interests, or activities) any individuals who actually have diagnosis of some ASD will not meet these new criteria; in addition, at present the criteria regarding the impairments in social interaction and communicative capacity are not require to be completely fulfilled. Consequently, the question arises whether S can meet these new criteria just as he met the necessary items from criterion A for the diagnosis of autistic disorder. To answer one might embed the criteria from the DSM-IV-TR among those from the proposed DSM-V criteria and see if S meets the criteria of the latter; thereby items A1c, A1d and A2b of the DSM-IV-TR are integrated into subdomain A1 (social-emotional reciprocity) of the proposed DSM-V criteria, because, indeed, the lack of shared enjoyment (item A1c) evaluates another aspect of the same symptom assessed by item A1d (socio-emotional reciprocity), and item A2b (to initiate or sustain conversational interchange) does too. On the other hand, subdomain A2 (nonverbal communication) includes item A2a (delay in spoken language) since this is evaluated by a failure to compensate through gestures [14]. Besides, subdomain A3 (deficits in relationships) contains the item on social imitative or make-believe play (A2d) because of the importance of these behaviors in early relationships [6]. Furthermore, stereotyped, repetitive or idiosyncratic language (item A2c) is integrated into subdomain B1 (Behavioral stereotypies) and the verbal rituals are integrated into the apparently inflexible adherence to nonfunctional routines according to the ADI-R [14]. Finally, criterion B of the DSM-IV-TR which requires abnormal functioning in social interaction, communication or play is replaced by criterion C in the proposed DSM-V criteria which only requires symptoms in early childhood [6,7].

Using the above method, one can see that S completely met the criteria proposed in the DSM-V for ASD, that is, the new criteria seem to confirm the diagnosis of ASD even more strongly than the DSM-IV-TR (Table 2).

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Summarized proposed DSM-V criteria	Summarized DSM-IV-TR criteria
A. Social communication and interaction	*A: 1. Socialization / 2. Communication*
1. Social-emotional reciprocity	1c *1d 2b*
2. Nonverbal communication	*1a* 2a
3. Deficits in relationships	*1b* 2d
B. Restricted and repetitive behavior	*A: 3. Restricted and repetitive behavior*
1. Behavioral stereotypies	*2c* 3c
2. Adherence to routines	*3b*
3. Interests and preoccupations	*3a*
4. Reaction to sensory aspects	*3d*
C. Symptoms in early childhood	B. Dysfunction prior to age 3 years
D. Impaired everyday functioning	----------
----------	*C. No Rett's or childhood disintegrative disorder*

Table 2. Comparison between the proposed DSM-V criteria for ASD and those from the DSM-IV-TR for autistic disorder: all text in italics represents each criterion and item met by Shereshevskii.

2.3. Some shared features with a case of synesthesia and Asperger syndrome

Daniel Tammet (DT) is a British writer born in 1979, who was diagnosed with Asperger syndrome (Asperger's disorder) by researcher Simon Baron-Cohen [8], so this paragraph does not discuss his diagnosis but the characteristics he has in common with S. Indeed DT has been named "the modern-day Shereshevsky" since he not only has an ASD but also phenomenal memory and synaesthesia. For instance, DT memorized and recited 22,514 digits of pi and has an extraordinary ability to learn to speak new languages [9]; similary S had the ability to memorize long chains of digits and reproduce several stanzas of *The Divine Comedy* fifteen years after having read it and despite not knowing Italian. However, both S and DT showed impaired face memory. Besides, with respect to synaesthesia, DT experiences numbers as having shapes, colour, textures, as well as some words with colour, while S also had synesthetic reactions whenever he heard tones, voices and speech sounds. Such reactions were puffs of steam, splashes, colourful visual flashes, flavours and even bodily sensations [1,9]. On the other hand, DT also has visual mental representations when he hears certain phrases, for instance, with "fragile peace" he imagines a glass dove, whereas with "election triumph" he sees the politician holding a trophy [9].

DT solved mathematical problems such as the following one through mental imagery: "There are twenty-seven people in a room and each shakes hands with everyone else. How many handshakes are there all together?" To solve this problem DT began imagining two men inside a bubble [9]; similarly, S solved the following problem: A husband says to the wife "Give me 7 of your mushrooms and I will have twice as many as you!" To which the wife replies: "No, give me 7 of yours and we will have the same amount". How many mush-

rooms does each have? In order to solve this problem S imagined himself with them (husband and wife) [1]. On the other hand, DT has also used mental imagery in order to better understand emotions. For instance, in order to empathize with someone who is sad, DT has imagined himself "sitting in the dark hollowness of number 6" [9]; similarly, S used his mental imagery, for example, during a very difficult performance S could see someone smiling in the audience, which was turned into an image of a sharp spire, so that he felt as if he'd been stabbed in the heart [1].

There are some differences between the symptoms from DT and S. Thus, whereas the neologisms from S were created by simple associations, the neologisms of DT such as "pramble" (to go out for a ramble with a baby in a pram) and "biplets" (twins) were created following more complex rules such as in the last neologism: a **bi**cycle has two wheels and a **tri**cycle three and three sisters might be a "**tri**plets". In other words, the neologisms from S were created through semantic or perceptual association, whereas those from DT were through morphological or syntactic analysis. DT has also shown impairment to initiate or sustain conversational interchange and both DT and S recognized that they were verbose and that this affected the conversations with others. DT also has difficulty understanding language, but whereas S believed that the phrase "the pressure is higher" meant that the gas was moved upward and consequently it could not dissolve in water [Luria], DT believed that the phrase "John is not tall, he is a giant" meant something impossible, although the phrase is not structurally different from the sentence "John does not have ten dollars, he has twenty", that is, it seems S had more problems in understanding the meaning of the words themselves but DT only with whole sentences. DT has shown problems to understand phrases such as "he is not inexperienced in such things" and likewise S could have had the same problems since he said he could not understand the negation of the negation [1,9].

3. Superior memorization as a cause of autism symptoms

3.1. Impaired and preserved memories in ASD

When Leo Kanner wrote his clinical description of autistic disorder, he pointed out excellent rote memory in children with the disorder and hinted that such an overload may be involved in the development of the disorder [3]. More recently it has been proposed that a mnesic imbalance may be the cause of all symptoms of autism, so the mnesic imbalance theory posits that all three diagnostic symptoms of autism may be explained by faulty procedural memory with relatively preserved declarative memory [12,29]. Procedural memory can be defined as behavioral algorithms that operate at an unconscious level and declarative (explicit) memory is information that is subject to conscious verbal reflection; whereas declarative memory includes episodic, semantic and working memory, procedural memory is only one of the various non-declarative (implicit) memories, such as priming, emotional conditioning and conditioned reflexes [36]. It is important to remember the latter because there are authors who may be referring to different types of memory although with the same term, for instance, procedural memory has been described as all implicit memory [37],

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whereas, other authors have pointed out that it is only a subtype [12,36,38,39]. In addition, a study in high functioning adults with ASD observed that memory for emotionally arousing events was preserved over time [40], and this preservation is particularly important for teaching new abilities to children with low functioning ASD [41].

The mnesic imbalance theory is supported by clinical studies that have shown bad procedural functioning [42-44], or good declarative functioning in individuals with ASD [45,46]. For instance, in a study utilizing the Serial Response Time Task (SRTT) with 10-element sequences to evaluate procedural learning in children and adolescents with autistic disorder, the results showed significant deficit in their procedural learning relative to Intellectual Quotient (IQ)-matched controls [43]. In contrast, some studies have challenged this finding, but it is important to note that all of these later studies had not use the same aforementioned task but rather tasks with 4-element sequences or shorter, as well as other changes in the application of the tasks [47-49], while significant improvement has been found in this sort of tasks in individuals with autistic disorder when the sequence length is short [50]. On the other hand, this deficit in procedural learning of sequences might be related to the poor short-term declarative memory shown on serial recall tasks in adults with ASD during a study, because its experiments demonstrated that their poor performance was due to faulty memory for the order of the items rather than because of memory deficit for the items themselves [51]. In other words, the difficulties in procedural learning of unconscious algorithms might lead to problems in learning explicit sequences, for instance, there are studies that have found impairment in "the delayed self-initiated execution of intentions at designated events" (called prospective memory), such as remembering to turn off the porch light at 11 pm or, to give a message to mom when she arrives [52-53].

Besides, a study utilizing a picture-naming task showed that boys with High Functioning Autism (HFA) responded faster than control boys on lower-frequency words; then, its authors argued that the results support the notion of enhancement in declarative memory of people with ASD [46]. This conclusion is based on the declarative/procedural model that assumes storage of grammar in procedural memory as well as of vocabulary in declarative memory [38]. In addition, such a model is in accordance with a meta-analysis which found that picture vocabulary tests are the peak of ability relative to verbal IQ in high functioning individuals with ASD [54].

Furthermore, a study utilizing a composite measure as an index of procedural learning showed significant negative correlation between procedural learning and autism symptoms [42]. Moreover, in another study, a composite group that included children with autistic disorder, both with non-functional verbal language and no spoken language, a significant positive correlation was observed between autism symptoms and scores of an index of declarative memory, which suggests that the imbalance between declarative and procedural memory in ASD might be more important than the mere faulty procedural memory [44]; such an imbalance might contribute to a global cognitive imbalance. This assumption is in accordance with results from a study in children with autism, which showed that those with a lower verbal than nonverbal IQ profile showed greater social impairment than those without this profile; this result was independent of scores in verbal or full-scale IQ [55].

Nevertheless, the mnesic imbalance theory does not suggest that declarative memory has to be above average in individuals with ASD; indeed, an impairment of episodic memory is in accordance with this theory [12]. In addition, the mnesic imbalance theory suggests that although procedural learning is significantly lower relative to declarative learning in individuals with ASD, this procedural memory can be developed [12,50]. Anyway, in this theory the imbalance between procedural and declarative memory is needed to account for the impairments in social interaction, communicative capacity and behavioral flexibility, as well as for the islets of ability and neurobiological findings observed in people with ASD [12,56].

However, it is important note that there are several deficits in declarative memory in individuals with ASD, but such deficits might be explained by overlap in the functioning of the memories. For instance, S and DT showed impaired face memory [1,8], which might be due to the difficulty to verbally describe all elements that make each face unique; consequently, facial memory has to be implicitly acquired through perceptual categorization, which is a type of procedural learning [57]. It is likely that some individuals with ASD see face learning as a task that should be performed by conscious memorization of each element of the face, which might explain the lack of developmental improvement in face learning that has been observed in autism [58]. Besides, utilizing functional magnetic resonance imaging, a study measured the activation over time of the amygdala in adults with ASD and the results showed a delay in the decrease of amygdala activity relative to control adults, which could be an action to improve face learning, since the participants with ASD had a reduction in the number of errors during a second set of the task of facial memory [59], while another study reported an association between increased amygdala activation and better facial memory in healthy people [60]. Furthermore, in individuals with autistic disorder, a study showed deficit of their facial memory awareness, that is, when participants were asked to say how they thought their performance in the task was, the answers did not correspond to reality [61].

The faulty perceptual categorization might be enough to explain the significant preference in individuals with ASD for utilizing an approach oriented to process parts rather than the gestalt during the Rey Osterrieth Complex Figure (ROCF) task [62]; this situation is equivalent to an increased number of elements, which might explain the difficulty for any individual with ASD to memorize the ROCF despite their tendency to use visual mental representations [26]. But the above mentioned deficit in facial memory awareness cannot be explained only by poor perceptual categorization. Another study showed that, whereas in typically developing adults the memory of actions is significantly better if the actions are self-performed (enacted) than if only observed, in adults with Asperger syndrome is not the case (Figure 1). These results were considered secondary to difficulties in encoding specific motor and proprioceptive signals [63], but an alternative explanation might be that during one's actions procedural knowledge is typically created and may aid declarative knowledge during recall, whereas in people with ASD, impairment of procedural learning prevents the appearance of such aid [12]. Consequently, if the latter explanation is used not only for motor actions but also for mental actions, then one might have an account for the deficit in facial memory awareness.

http://dx.doi.org/10.5772/54295

Impaired procedural memory is not only unable to aid declarative memory, but that declarative memory also has to replace faulty procedural memory in some of its functions, which implies an overload for consciousness. This assumption is in accordance with a study that showed that children with ASD, in comparison to the control group, had significant difficulty in divided attention (ability to simultaneously perform two independent tasks), which was significantly related to everyday working memory [64].

The above findings are in accordance with a review of memory in ASD that pointed out a deficit in episodic memory, but are not in accordance to its assumption of preserved memory for non-social stimuli [65]. On the other hand, one must keep in mind that although there are deficits in encoding and organization of episodic and autobiographical memory in people with ASD, their storage and retrieval are preserved [66,67].

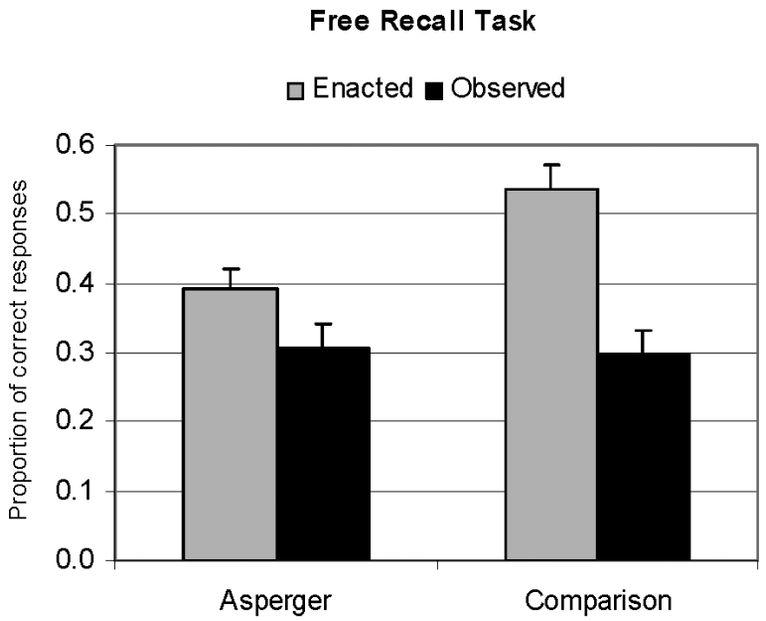

Figure 1. Mean of correctly recalled items of the Free Recall Task of actions (Enacted and Observed) in Asperger and Comparison groups: The bars represent means and the whiskers represent standard error (From Zalla et al., 2010).

3.2. Reduction of autism symptoms during the mnemonist job

In the first clinical description of autistic disorder, it was suggested that excellent rote memory might be involved in its etiology, since some children described by him could recite verbatim the "questions and answers of the Presbyterian Catechism", the "Twenty-third Psalm", poems, as well as titles and composers of Victrola record pieces but were unable to initiate or sustain conversations with others [3]. On the other hand, some authors have thought that S could have had an ASD [4,5]; it has been surmised that his astounding memory interfered with his comprehension of what he heard or read [5,68]. However, such an assumption might be inaccurate because his cognitive difficulties could be due to the ASD he suffered, not to his memory. So, the mnesic imbalance memory posits a higher tendency to

use explicit (visual) mental representations in people with ASD to solve problems [12]. Similarly, a study of individuals with declarative memory deficits due to neurological damage showed that creating mental imagery of events from a personal perspective may improve episodic memory [69], therefore, people with ASD might try to improve their poor episodic memory through mental imagery. In addition, another study found that mental imagery was effective at enhancing the task of relearning after brain injury [70], so mental imagery might be used against motor deficits secondary to faulty procedural memory [12]. Finally, other study reported that understanding expressions (idioms) is associated with more sophisticated and figurative mental images [71]; consequently, the creation of mental images in people with ASD might be a small successful attempt in order to understand abstract thinking as well as mental states of others, for example, mentalizing deficit in children with autistic disorder was initially tested using the unexpected transfer test of false belief [20], but both typically developing 3 year olds and children with autism significantly improve on that test when they use thought bubbles, that is, visual representations of mental states [72,73]. In addition, a review supports the ''Thinking in Pictures'' hypothesis, which posits that a subset of individuals with ASD shows disposition towards using visual mental representations, although the authors of that theoretical proposal make the assumption that in people with ASD, mental imagery creates difficulties for understanding [26]. In view of this scenario, it is possible that neither his astounding memory nor his encompassing preoccupation for very detailed and specific visual mental representations were the cause of the cognitive problems of S, but rather some other factor might be the cause of these three features in S and such a factor might be the mnesic imbalance since procedural memory seems to be required for the development of analogical inference, which is a sort of reasoning performed primarily through unconscious algorithms that might be at the heart of abstract thinking and verbal comprehension [74-76]. So, if it is difficult to perform reasoning through procedural memory then that might be tried through declarative memory using explicit (visual) mental representations [12]. So, it is very likely that this was the reason why S often said "I can only understand what I can visualize" [1].

It has been surmised that the mnemonist job could exacerbate autism symptoms in S [4]. However, the symptoms appear to have decreased precisely because of that job. For instance, the encompassing preoccupation with very detailed and specific visual mental representations that he did for his job was very exhausting, so S decided to make his visual mental representations more and more simple; as a result, the word *restaurant* was no longer represented by "its entrance, people sitting inside, a Romanian orchestra tuning up, and a lot else", but by "an entrance way with a bit of something white showing from inside", while with the word *airport,* S could see only "a small segment of the Leningrad Highway". This simplification of the visual mental representations allowed him to better understand and to enjoy what he heard and read. Also, S showed a decrease of the apparently inflexible adherence to nonfunctional routines, for example, if S heard the word *America*, he no longer needed to do his mental journeys, but just to imagine "Uncle Sam". In addition, S learned to follow conversations and to understand when his behavior was not tactful [1]; similarly, a man with autistic disorder named Peter Guthrie and another man with an ASD named Kim Peek, who were used as models to create the character with autistic disorder in the movie

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Rain Man also showed significant improvement in socialization and communication after the increase in their public activity [77,78].

3.3. Relationship between great mnemonists and ASD

There are several cases of individuals with ASD that have been known for their astounding memory, for example, Kim Peek learned more than 12,000 books and his encyclopedic knowledge covering at least 15 interests such as world and American history, sports, movies, geography, actors and actresses, literature and classical music. Peek as S had significant difficulties with language comprehension, for instance, once when Peek was asked to "lower his voice" he only slid lower into his chair [78,79]. Also, Peter Guthrie has an extraordinary memory: he can say the day of the week for any date between past and future decades, has memorized the Billboard record-sales charts and an extraordinary amount of data from almanacs and newspapers; he reads, writes and pronounces English, Japanese, French, Arabic and Spanish [77]. Moreover, a mental calculator described in his book the case of an elderly man with ASD who could tell what day of the week any given date fell, because he remembered the day of the week and an event of dates that he had lived [80], while another author described twins, John and Michael who also recalled a great amount of events from their own life, but in addition, they could say the day of the week for any date in a period of 80,000 years [81]. It is interesting to note that although bad episodic memory in people with ASD has been mentioned, these cases showed an extraordinary amount of autobiographic remembrances, even S not only remembered the hundreds and thousands of series of numbers, words or syllables, but also the whole scene in which the learning had initially been carried out, so he said "This was a series you gave me once when we were in your apartment... You were sitting at the table and I in the rocking chair... You were wearing a gray suit and you looked at me like this..." [1].

On the other hand, a woman named Jill Price (whose pseudonym in scientific literature is AJ), remembers almost every day of her life since age 11. This feature is considered part of a disorder for which the phrase "hyperthymestic syndrome" (hyperthymesia) has been coined [2]. However, another author has considered the possibility that her hyperthymesia is only a sort of obsessive compulsive disorder since she spends excessive amounts of time reliving past events and although says this is a burden also says "when I think of these things it is kind of soothing" [82]. On the other hand, S showed an apparent obsessed worry by his memories when he said "I both did and didn't want it to appear". However, this was a worry about an apparent real-life problem, because S left his job as a journalist after meeting Luria, then S became a professional mnemonist who performed on stage memory acts to entertain audiences; he often gave several functions each evening and feared he began to confuse the individual functions. Consequently, S tried to forget what he had memorized in previous functions, but finally, he understood that memories only appear if he wanted it. This latter situation was interpreted by Luria as S had learned to forget [1], but such assumption is inaccurate because it is different forget than to only remember when one wants to. Thus, it is likely that S was finally able to answer the question "Isn't it confusing to remember so much?" as the professional mnemonist without ASD Harry Lorayne, who acted

before S died and whose response was "No!" [83]; contrary to S, he had a very good empathy and extraordinary memory for faces, so he could memorize the name of 700 individuals in only one function [10].

Hyperthymesia is also called Highly Superior Autobiographical Memory (HSAM); an author with HSAM (and without ASD) has claimed that this is not a disorder, but is "almost like therapy, in that it helps you to better understand yourself and predict how you'll function" [84]. It has been suggested that studying cases of hyperthymesia may provide the basis of potential future treatments for patients with memory disorders [85]. Furthermore, other cases of superior memory studied by science are those individuals without ASD that have set a Guinness World Record by memorizing thousands of digits of pi, for example, Rajan Mahadevan, whose memory allowed him to recited 31,811 decimals of the mathematical constant pi, shows his ability to recite a random sequence of over 40 digits seen by him at the rate of a digit per second during a digit span test [86], whereas Hideaki Tomoyori, could recite the first 40,000 digits of pi, had an average visual digit span of 8, but 10 in the auditory digit span [87]; likewise, Chao Lu established the Guinness World Record at 67,890 decimals of pi and could remember a mean of 8.83 digits during the visual digit span task [88], whereas Dominic O'Brien (with at least six World Memory Championship titles), memorized a random sequence of 74 digits in the auditory digit span task [11]. These data indicate that the digit span tasks are not useful to show the superior memory of some individuals without ASD, such as Hideaki Tomoyori and Chao Lu. This situation does not seem to be different in people with ASD since DT, who was diagnosed with Asperger syndrome and recited 22,514 digits of pi, had a mean of 11.5 digits on a visual digit span task [8]. In contrast, when these individuals are allowed self-paced learning they can demonstrate their superior memory; for instance, Tomoyori perfectly remembered the 25 digits from a 5 X 5 number matrix studied for 233 seconds, that is, at a rate of 9.32 seconds per digit, whereas his control group recalled only a mean of 18.30 digits of that matrix studied at an average of 395.6 seconds (15.82 seconds per digit) [87]. Besides, Chao Lu also perfectly recalled all matrices, such as one of 25 digits which he studied for 35 seconds (1.4 seconds per digit), whereas with a 7 X 7 number matrix he required 260 seconds (5.31 seconds per digit) and on a 9 X 9 matrix he used 387 seconds (4.78 seconds per digit) [88]. Likewise, S also demonstrated his superior memory through self-paced learning, for instance, he correctly recalled all 20 digits from tables of numbers that he memorized in a mean of 37.5 seconds (1.8 seconds per digit), he learned tables of 50 digits in 165 seconds (3.3 seconds per digit). He recalled the third vertical column of these later tables in 80 seconds, recalled the second vertical column in 25 seconds, which suggests that S did not memorize the tables as a mental photograph but as a chain of data with a determined order [1]. This same pattern has been observed in Tomoyori who also used mental imagery [87]. Indeed, according to the occipital activation that is observed in mnemonists with and without ASD, even if there is no success in the memorizing, both groups use visual mental representations during recordings [89,90]. In addition, other features of neurobiological similarity between people with ASD have been observed as well as in those whose declarative memory has been significantly enhanced [56]. Even children with Low Functioning Autism (LFA) may show qualitative similarity with the great mnemonists without ASD. For instance, some of them can learn to read whole sentences at pre-

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school age despite their very poor language comprehension [3,77,78,91], besides, the great mnemonists can learn large amounts of text quickly [10,11]. Also the delayed echolalia in children with LFA is a demonstration of good declarative memory [3,27]. On the other hand, skills such as calendar calculation are common among the great mnemonists without ASD and in some individuals with HFA or Asperger syndrome. Indeed DT, Kim Peek and Peter Guthrie made calendar calculations [9,77,78]. To summarize, figure 2 illustrates the differences and similarities between people whose declarative memory has been significantly enhanced and that have an ASD regardless of whether or not they have an extraordinary declarative memory.

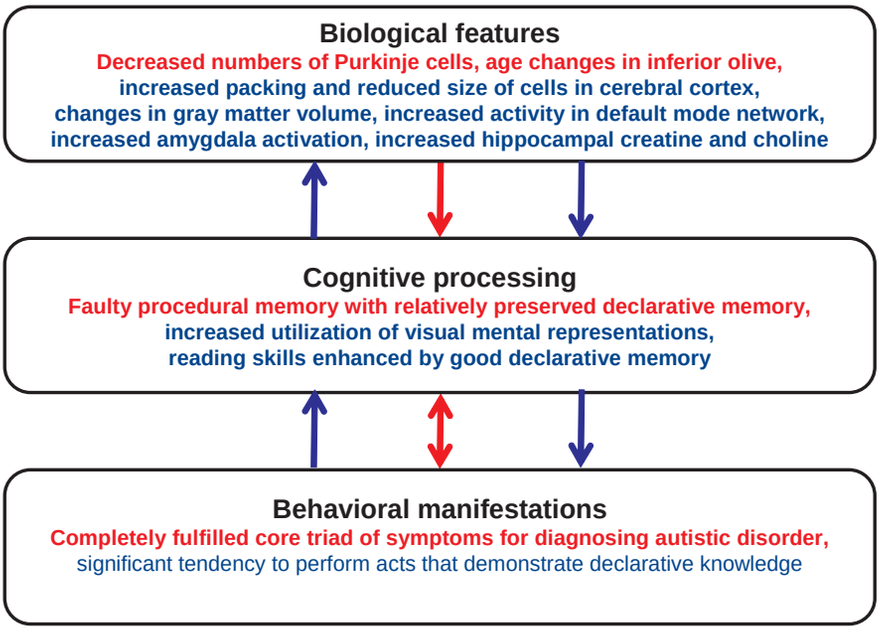

Figure 2. Shared characteristics between people with ASD and those whose declarative memory has been significantly enhanced (in blue text), and those only present in people with ASD (in red text). The blue arrows suggest a reciprocal causal interaction among all shared characteristics, whereas one red arrow indicates unidirectional influence and the other one bidirectional influence.

4. Mmesic imbalance and superior memory in autism spectrum disorders

Mnesic imbalance theory predicts a higher tendency in individuals with ASD to use visual mental representations [12,56], these types of representations may be utilized to significantly enhance declarative memory [11,83,92]. Luria recognized that this mental imagery was the cornerstone of S's extraordinary memory, whereas the synesthetic experiences were additional information [1]. So for instance, a study of individuals with synaesthesia shows that they have better memory than controls for data that induce synaesthesia, as well as for color

per se [93]. However, during the World Memory Championships the competitors currently use mnemonic methods, not innate features as synaesthesia; one of these mnemonic methods is "the method of loci" [94], which was used by S, who when he listened to a list of objects to memorize he would distribute them along a street in his home town or the Gorky Street visualized in his mind [1]. "The method of loci" is used by Buenos Aires waiters, who memorize all the orders without written support [95].

Lorayne has pointed out that it is difficult to remember the abstract, he therefore recommends replacing it by tangible objects, for example, 7 might be represented by a flag, whereas 8 by an hourglass [10], while S used a man with a mustache to represent 7 and a very stout woman to represent 8 [1]; O'Brien said that 07 may become James Bond [11]. Finally, it is very difficult to memorize meaningless words, but a solution is to convert those words into intelligible images, for instance, the name "Olczewsky" was imagined by Lorayne as an *old* man *chew*ing, while he *ski*ed [83], while S visualized the word "mavanasanava" as his landlady speaking (Polish: mówić = to speak) from the window, pointing into our guesthouse (Russian: наши = our) and making a sign of negation (Latvian: nava = is not a) with her other hand [1].

5. Conclusion

The astounding memory of Shereshevskii has been taken as a paradigmatic example of how the development of a skill can affect the development of others. However, this chapter has offered arguments against such a view and presented evidence that he had an ASD. In addition, the relationship between memory and autism can be better understood if we reanalyze the life of this extraordinary individual under the light of the mnesic imbalance theory.

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Author details

Miguel Ángel Romero-Munguía

Address all correspondence to: romero_munguia@yahoo.com

Outpatient Service, "Dr. Samuel Ramírez Moreno" Psychiatric Hospital, Health Secretariat, Mexico

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