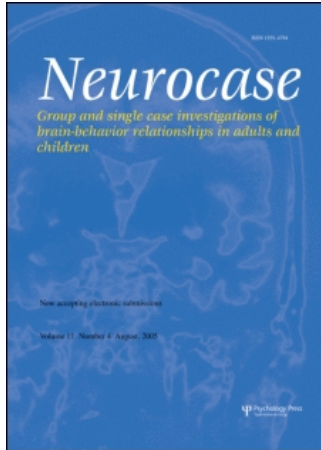


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A Case of Unusual Autobiographical Remembering

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This report describes AJ, a woman whose remembering dominates her life. Her memory is “nonstop, uncontrollable, and automatic.” AJ spends an excessive amount of time recalling her personal past with considerable accuracy and reliability. If given a date, she can tell you what she was doing and what day of the week it fell on. She differs from other cases of superior memory who use practiced mnemonics to remember vast amounts of personally irrelevant information. We propose the name *hyperthymestic syndrome*, from the Greek word *thymesis* meaning remembering, and that AJ is the first reported case.

Introduction

What would it be like to live with a memory so powerful that it dominates one’s waking life? We present here the case of AJ, a woman who told us:

My memory has ruled my life... It is like my sixth sense ... There is no effort to it ... I want to know why I remember everything. I think about the past all the time... It’s like a running movie that never stops. It’s like a split screen. I’ll be talking to someone and seeing something else ... Like we’re sitting here talking and I’m talking to you and in my head I’m thinking about something that happened to me in December 1982, December 17, 1982, it was a Friday, I started to work at Gs (a store)... It’s all about dates... I just know these things about dates... I used to spend all my time thinking about dates... When I hear a date, I see it, the day, the month, the year... I can go back over the years since 1980 on a date ... When I hear a date I see the day... I see it as I saw it that day ... I get to a portion of the day so I can see what day it was and whatever sticks out in my mind... I only have to experience something one time and I can be totally scarred by it ... I can’t let go of things because of my memory ... Happy memories hold my head together ... I treasure these memories, good and bad... I can’t let go of things because of my memory, it’s part of me ... When I think of these things it is kind of soothing ... I knew a long time ago I

had an exceptional memory ... I don’t think I would ever want to have this but it’s a burden.

These are quotes from various conversations we have had with A.J.

This delightful and fascinating woman contacted JLM with the following email that describes in her own words her extraordinary recollective abilities and how they impact her life:

*Dear Dr. McGaugh,
As I sit here trying to figure out where to begin explaining why I am writing you and your colleague (LC) I just hope somehow you can help me.*

I am thirty-four years old and since I was eleven I have had this unbelievable ability to recall my past, but not just recollections. My first memories are of being a toddler in the crib (circa 1967) however I can take a date, between 1974 and today, and tell you what day it falls on, what I was doing that day and if anything of great importance (i.e.: The Challenger Explosion, Tuesday, January 28, 1986) occurred on that day I can describe that to you as well. I do not look at calendars beforehand and I do not read twenty-four years of my journals either. Whenever I see a date flash on the television (or anywhere else for that matter) I automatically go back to that day and remember where I was, what I was doing, what day it fell on and on and on and on and on. It is non-stop, uncontrollable and totally exhausting.

Some people call me the human calendar while others run out of the room in complete fear but the one reaction I get from everyone who eventually finds out about this “gift” is total amazement. Then they start throwing dates at me to try to stump me... I haven’t been stumped yet. Most have called it a gift but I call it a burden. I run my entire life through my head every day and it drives me crazy!!!... .

It was with great skepticism and curiosity that we met AJ. Over the past five years, she has graciously consented to being queried and probed about her memory, tested with novel and

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We are indebted to AJ for her eagerness to share her time and her story for science. Her willingness to be queried, probed, tested, and videotaped has been unwavering. AJ knew that she possessed a unique memory and told us over and over that she hoped understanding it might some day help others. We thank Endel Tulving for his help with this conceptualization of AJ’s remembering. We thank Spiros Koulouris for his input on naming the syndrome.

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standardized tests, and shared her personal experiences with considerable openness. It became clear, early on, that her memory was different from other cases of superior memory reported in the literature. She was not gifted at encoding and retrieving long strings of digits and numbers. Over and over again, she told us that her memories are deeply personal, tied to what she is interested in, closely linked to dates that are within her personal experience and uncontrollable. So unique is her presentation that we decided to let the subject herself guide this inquiry.

In contrast to the vast literature on impaired memory and the amnesic syndrome, relatively little is known about forms of superior memory. Previously reported cases of superior memory seem to have in common the ability to perform memory feats with meaningless information such as learning long displays of words or digits and repeating them back. None were reported to have superior autobiographical memory or to be bothered by constant remembering of personal experiences. Luria (1987) wrote in detail about the superior memory of S, who became a professional mnemonist and earned his living by amazing audiences with his ability to recall almost limitless amounts of information. S was not bothered by an extraordinary autobiographical memory, indeed he was described as living his personal life "as in a haze" (p. 159). Nor did S think of himself as having an exceptional memory. When sent to Luria for examination by the editor of the newspaper where he was then working as a journalist, S was perplexed as to why he had been singled out. He did not see his memory as unusual or remarkable. Nor is there evidence of remarkable autobiographical memory in VP, another case of superior memory described by Hunt and Love (1972, 1983). VP was a man who could play up to 60 games of correspondence chess without notes, and who, by the age of five, had memorized the street map of Riga, his home town of 500,000 people. VP memorized Bartlett's tale, "War of the Ghosts" producing it nearly verbatim after two readings and a year later without warning was able to recall the tale as he had the year before. VP did not see his memory as above the norm. In fact he told Hunt and Love that many of his fellow classmates had better memories than his, as the educational system in Riga placed such strong emphasis on rote learning. TE reported by Gordon *et al.* (1984) began studying mnemonics at the age of 15 and could memorize eight rows of six digits using complex strategies. In their path-breaking book on superior memory, Wilding and Valentine (1997) have written in depth about ten cases. The majority of their cases had either performed or been spectators at the World Memory Championships where people perform feats such as learning and remembering long strings of binary digits. Wilding and Valentine found that their ten cases each had very different but highly domain-specific forms of superior memory. For example, their Subject A had worked as a telephone operator and was able to recall nearly all the telephone exchange codes of the British Isles in response to town names (p. 119). According to

Wilding and Valentine (1997, p. 159), none of the ten cases, despite superior ability on laboratory memory tasks, had more than average ability to recall autobiographical detail from their past.

The current view of superior rememberers studied to date is that their skills are due to the application of strategies acquired through practice, and not to innate abilities (see Ericsson *et al.* 2004). AJ seemed to differ from this characterization as she told us she could not consciously apply strategies to help her learn and retain new information. She was not able to use her talents to memorize in school, telling us she had great difficulty with rote memorization. She repeatedly told us her memory was automatic, not strategic. Luria studied, in considerable depth, the mnemonic strategies used by S, including visual images and his complex synesthetic constructions that allowed him to retain prodigious amounts of information for years. Maguire *et al.* (2003) asked their ten cases with superior memory about mnemonic strategies they used to remember memory tasks during a brain fMRI. All ten reported using mnemonics and nine reported using the "method of loci" for some or all of the tasks. The method of loci is attributed to the Greek poet, Simonides of Kos in 447 BC (Yates, 1966) and basically consists of taking a mental walk through a familiar route, attaching to-be-remembered items to places along the route which in turn serve as retrieval cues during another mental walk at retrieval. Luria's case S, with his rich capacity for visual imagery, used a variation of the method of loci to recall strings of 50 to 70 words and digits, which he could recall both forward and backward depending on where he started his mental walk at retrieval. Ericsson *et al.* (2004) undertook extensive reevaluation of the famous Rajan (Thompson *et al.* 1991), who had superior abilities to remember digits and letters. They concluded that his memory skill was due to encoding techniques he had acquired through extensive practice, and not to an innately superior memory.

Luria's classical study of S influenced our approach to AJ. Luria carefully described S's memory skills and abilities in the context of the total person, considering his memory skills as part of and causally related to his overall psychological makeup. Most psychological studies of superior rememberers have focused on laboratory tasks to document subjects' memory performance, with less attention to the cases' broader psychological makeup. Surprisingly little has been written about how a superior memory relates to the person's inner makeup or how it affects their everyday functioning. In addition, very little is known about neuropsychological domains outside memory in cases of superior memory. General intellectual functioning, as measured by tests of IQ (e.g., Wilding and Valentine, 1997; Maguire *et al.*, 2003), has not been found to correlate with superior memory. Interestingly, Luria reported that S was viewed by people as disorganized and dimwitted, and had trouble with abstraction. We therefore undertook an extensive neuropsychological evaluation of AJ, to examine her memory performance on standard clinical

instruments and to examine her memory in the context of her overall neuropsychological profile.

Methods

Research data were collected through a protocol approved by the University of California, Irvine IRB and informed written consent was obtained from AJ. Much of the research methodology was guided by what AJ told us and we observed. We interviewed her extensively about her history and her memory. We made video recordings to study her in depth. AJ was never told what she would be asked about or tested on in advance. She arrived at each visit completely naïve about dates and events that would be queried on that day. Her recall of dates and events from her own life were noted for their high reliability. As AJ kept a diary from the age of 10 to the age of 34, a subset of her personal recollections was verified with her diary entries. This verification occurred by asking her to bring a box of her diaries and then checking in the diaries a subset of dates for which she had, in earlier meetings, provided us an account of events. Her mother verified some facts. Her ability to recall dates and newsworthy events was tested from a book of news events over the past 100 years (Lucas, 2000). Her ability to tell what day of the week was a certain date was checked from calendars. Results are presented in a manner to protect AJ's confidentiality and privacy.

Formal neuropsychological testing was conducted by a clinical neuropsychologist (ESP) according to standard clinical procedures and interpreted according to relevant norms. Each test is described in Lezak (1995) except for tests from the Delis-Kaplan Executive Function System [(D-KEFS) Delis *et al.* 2001]. Clinical tests of memory are designed to measure memory deficits, not superior memory, and can suffer from ceiling effects. It is noted where AJ's scores were at the maximum possible. Memory tests included: *global memory indices* (Wechsler Memory Scale Revised (WMS-R)); *memory tests requiring organizational strategies* [word-list recall (California Verbal Learning Test-Research Edition (CVLT)); and recall of complex visual information (Rey-Osterrieth Complex Figure Test (Rey-O CFT)); *memory tests with strong external cues* (Warrington's Word and Face Recognition Tests; paired associates from the WMS-R; recognition on the CVLT); *working memory* (Letter-Number Sequencing subtest of the Wechsler Adult Intelligence Scale – III (WAIS-III), maximum number of digits in the reverse directions and maximum number of items in reverse visual span from the WMS-R); *semantic memory* (Information subtest of WAIS-R); and *autobiographical memory* (Autobiographical Memory Index (AMI)).

To measure neuropsychological domains beyond memory, the following domains and tests were selected: *General intellectual functioning* (Wechsler Adult Intelligence Scale-Revised (WAIS-R)); *lateralization* (Edinburgh Handedness Inventory, Grooved Pegboard Test and Finger Tapping Test);

executive functions (Wisconsin Card Sorting Test, Halstead Category Test, three subtests of the D-KEFS namely the Sorting Test, Twenty Questions Test, Proverbs Test and Tower Test; the Stroop Test; written fluency, i.e., generation of words beginning with the letter S and four-letter words beginning with C, with five minutes allowed for each letter, letter and category fluency from the D-KEFS, Ruff Figural Fluency Test; and Trailmaking Tests Parts A and B); *language functions* (Boston Naming Test, Reading and Spelling sections of the Wide Range Achievement Test-Revised (WRAT-R), Vocabulary and Comprehension subtests of the WAIS-R); *visual spatial functions* (Picture Completion, Picture Arrangement, Block Design and Object Assembly subtests from the WAIS-R, ability to copy the Rey-O CFT, Benton Face Recognition Test, Hooper Visual Organization Test); *calculations* (Arithmetic portion of the WRAT-R and Arithmetic subtest of the WAIS-R); *visual-motor functions* (Digit Symbol subtest of the WAIS-R, and Symbol Search subtest of the WAIS-III).

Results

Background Information

Family History

AJ was born in 1965 after a normal pregnancy and delivery to a family she describes as "close and protective." She has one younger sibling, a left-handed brother who is nearly four years her junior. Her father is a businessman and her mother works as an assistant in a medical office. The family is Jewish with her father's parents coming from Hungary and Russia, and her mother's parents coming from Germany and Romania. Family history is positive for depression, anxiety and ocular migraines. According to AJ, several other members of her family have good memories but nothing like hers with her phenomenal memory for dates. These other relatives are a paternal aunt, paternal cousin and paternal great uncle. She was married for the first and only time at the age of 37.

Development of her Memory

AJ reports that her earliest memory is being in her crib, around the age of 18 to 24 months, and frightened when woken by her uncle's dog. She says she can recall her brother's birth when she was three years, nine months old. According to AJ she had always had a richly detailed memory for episodes but there was a change in her memory when at age eight her family moved from the east coast to the west. She reports she had loved their life in the east and did not want to move. She says she was "traumatized by the move" and that after the move she started to "organize her memories," making lists of friends from back east, looking at pictures of her house and thinking about the past "a lot." She states that after the move, her memories became "clearer." In 1976 when she was ten years old she began keeping a diary.

She says that she first became aware of her detailed memory in 1978 at age twelve. She told us the same story on several different occasions. She recalls that she was studying with her mother and started to drift off thinking about the year before in school, which she had “loved.” It was then she says she became aware that she was able to vividly recall the details of the year before and exact dates. From 1974–1979, ages eight to thirteen, she can remember many days but not every day. She often has to think about things (for a few seconds). As the years went by, she remembered more and more dates and events. She says that from 1980, age 14 onward, her recall became “automatic”... “give me the day and I see it. I go back to the day and I just see the day and what I was doing.” Her mother reports that the family noticed AJ’s superior memory when she was in her twenties.

Diaries

From the age of 10 to the age of 34, AJ kept diaries, nearly every day. Her diaries were various forms of scheduling calendars with small entry areas, some just one inch by one inch. Some years, her entries were completely filled with writing so micrographic that even AJ read them to us with great difficulty. Other years, her entries were less detailed, and more readable, with 6–7 brief entries per day. She said that she was “obsessed with writing things down” because things would stay in her mind if she didn’t write them down in her diary. It made her feel better to have things written down. She said she rarely went back to review them. These diaries provided a resource for our verification of her recollections.

Educational History

Despite her remarkable memory, AJ reports that she never excelled in school and says she “hated” it. She insists that she must be interested in something in order to remember it. She said her grades were mostly Cs with some Bs and an A here and there. When asked why she didn’t apply her great memory to school, she said “It (meaning her memory) doesn’t work that way. I had to study hard. I’m not a genius.” She reports she had trouble memorizing dates in history, arithmetic, foreign languages, sciences and “got Ds in geometry.” She told us she received an A in algebra which came much more easily to her. She said she had math tutors from second grade to help her memorize math facts. She readily admits that she “hates authority” to which she attributes her dislike of school. Memorizing poetry was painfully difficult. Yet she can recall with ease every one of her teachers since kindergarten. She did complete a bachelor’s degree in a social science, graduating at the age of 23.

Occupational History

AJ has had periods where she has been unemployed by choice. Upon returning home from university, she worked for a year in the entertainment field. This was followed by a three-year period, when she was 25 to 27, where she did not

work and lived at home with what she describes as “an extreme bout of depression.” She then worked as an assistant in a law office where her memory for events and dates was a significant asset. After that, she worked as an executive assistant for the next six years until she married. AJ’s goal is to be a wife and have a family, rather than having a career outside the home. That is all she has wanted since she was three years old. She is working on plans to start her own business that involves selling a product she will make.

Medical and Psychological History

She reports migraines since childhood, about five times a year up to her early thirties, when she took 5 ibuprofen tablets every day to prevent headaches. She stopped the Advil at 37 and only had one migraine in the year and a half since then. She was sickly until the age of five suffering frequent sore throats and ear infections. Surgeries include tonsillectomy at age four and two facial reconstructive surgeries following an automobile accident when she was 16. There was no reported loss of consciousness from this head injury or another when she hit her head at age eight. Lactose intolerance developed when she was 30 and lasted until she was 33.

AJ told us she had taken medication “for anxiety” “for years,” initially Prozac and later Zoloft (200 mg a day). On her own, she tapered off Zoloft but with some difficulty, experiencing significant gastric distress and “twitching.” During her period of depression, from the ages of 25–27 as described previously, she underwent counseling but was not put on medication. She had counseling on and off from the ages of 26 to 35. There is a history of sleep problems with insomnia that stopped when she was in her early thirties. She has not had insomnia in nearly seven years.

AJ reports having numerous “phobias” but does not think there is any relationship between her memory and her phobias. Early on she told us she was “phobic” about doctors, hospitals and universities, making us wonder how she would take to participating in research in a university setting. This has not turned out to be a problem, for reasons she explains only that “this is different.” One day she brought in a list of phobias with twenty items checked. She recalled that her bird phobia started on July 16, 1988 when she was hit on the head by a pigeon. She also listed as phobias: bird droppings, stage fright, rats, and many specific foods and smells. She can name the dates and events that triggered many of the “phobias.”

AJ told us that she has “always needed order” in her life. She told us she was “traumatized” by the family move from the east to the west coast and is insistent in her belief that this trauma changed her memory. She refers to herself as a “neat freak” and recalls even when she was three years old, she insisted on keeping her dolls in a very “precise and complicated order” in her doll carriage. She recalled that around the age of five she would “throw a fit” if anyone moved things in her bedroom. She said she would “go nuts and get hysterical

because things were moved.” Her attachment to her family, familiar places and things is a frequently repeated theme. She told us that up to the age of five she would “cry hysterically” if her parents went out. After that she continued to have “severe separation anxiety” about her parents. She has lived with her parents most of her life, even after she married. Shortly after her marriage, she and her husband somewhat abruptly packed up and moved to another part of the country only to immediately turn around and return to her parents’ home. When AJ was 37, her parents sold the family home where she had lived most of her life. She was most upset about having to pack her life’s treasures and leave the bedroom which had remained pretty much in the same state as when she was nine. These descriptions fit with her reported history of anxiety.

Her knowledge of and interest in certain television programs is remarkable and she collects TV guides. She says she is “fascinated with the macabre.” She says she is a very social person and interested in people. She is the family historian and her friends turn to her to remember things they did together and when.

Behavioral Observations

AJ has been extremely co-operative and open during these investigations. She clearly enjoys telling us about her memory and can talk at great length about events from her personal past. For example, when asked about her second grade teacher, she, without hesitation, provided the name and described with considerable positive affect the teacher, her appearance, and information about the teacher. AJ’s recall of events from her past is immediate, confident, and with considerable emotion. She lights up when she recalls. If she does not know the answer to a question, she says she doesn’t know. She did not confabulate or guess. She told us often that she could not remember something because she did not care about the topic or the question was outside the time period of her memory calendar (generally 1974 to the present).

AJ did not enjoy being asked questions she could not answer nor did she like neuropsychological tests on which she had difficulty. For example, she told us in no uncertain terms that she did not like the word-list recall tests. She said she “hated” trying to recall the “War of the Ghosts” story. During the Halstead Category Test of executive functions she repeatedly said she hoped the test would be over soon. This pattern of discomfort and even antipathy towards certain tasks contrasts with her engaging affect when recalling stories and dates from her personal life.

Examples of AJ’s Associative Autobiographical Recollections

She says her personal memories are vivid, like a running movie and full of emotion. As described in the Introduction, AJ told us that her remembering is automatic and not under

her conscious control. Her answers were immediate and quick, not deliberate and reflective. Once given a date within her period of strong memory she would, within seconds, produce the day of the week, or what she did on that day, or what event took place on that day. If allowed to talk uninterrupted, AJ would go on at length telling stories about what she did on that day, or something she did before or after that day, such as a trip home from college with a friend, or the restaurant where she ate and with whom. Although she can recall dates and events with incredible accuracy, her memory is deeply personal. A date, a public event, the name of a television program, the name of a public figure can cue her personal recollections, seemingly effortlessly and automatically.

One recollection for AJ cues another and another and another, linking one recollection to the next, as if her retrieval mode, once turned on goes on automatic. For example, when asked about JFK Jr’s fatal plane crash, she immediately told us it had occurred on July 16, 1999. She spontaneously associated to what she was doing, telling us “I just remember they had flown away on Friday night and on Saturday morning I remember being like almost asleep because I sleep with the TV on and I probably had the news going and it was like seven o’clock in the morning. I remember hearing this and sitting up and thinking I didn’t hear what I just heard. I lay down for two hours listening.”

Another example of how one recollection cues the next was illustrated when she wrote about how watching a television program can cue emotional memories from her personal past. She wrote: “The Waltons ... I will think about my Grandmother (because we used to watch the show together) who died 15 years ago this May and I will also think about how much I miss the 1970’s and then memories start to flood my brain. I get that 1970’s “feeling” (what that decade felt to me). There are other shows that give me that same feeling. For instance, I just found the music for the CBS Movie of the Week from 1974 and I play it over and over while I am on the computer because it gives me a “safe” feeling.”

Dates as Cues for Personal Recollections

When given a specific date she would immediately, and without prompting, tell her recollections. She did not know in advance what dates we would ask her about, so there was no opportunity for preparation or rehearsal. It is noted where events were later verified from her diary.

April 3, 1980? – “I see it. Spring break. Passover, I went to that week. I was on Spring Break. I see the week. I was in 9th grade. The week before I was on Spring Break. I was into General Hospital.”

July 1, 1986? – “I see it all, that day, that month, that summer. Tuesday. Went with (friend’s name) to (restaurant name).” Day of week correct, event later verified from her diary.

October 3, 1987? – “That was a Saturday. Hung out at the apartment all weekend, wearing a sling – hurt my elbow.” Day of week correct. Entry later verified in diary.

April 27, 1994? – “That was Wednesday. That was easy for me because I knew where I was exactly. I was down in Florida. I was summoned to come down and to say goodbye to my Grandmother who they all thought was dying but she ended up living. My Dad and my Mom went to New York for a wedding. Then my Mom went to Baltimore to see her family. I went to Florida on the 25th which was a Monday. This was also the weekend that Nixon died. And then I flew to Florida and my Dad flew to Florida the next day. Then I flew home and my Dad flew to Baltimore to be with my Mom.” Day of week correct.

The Easter Test for Recall of Dates and Personal Events

AJ told us on many occasions that she could “see the day” particularly after age 13, and all other days with that same date. In 2003, we decided to test this by asking her to write down all the Easter dates from 1980 onward. In ten minutes, with no prior warning, she wrote the 24 dates presented in Table 1. All but one date is accurate and it is off by two days. This struck us as particularly impressive in that Easter falls on different days, anywhere between March 22 and April 15, based on the Paschal full moon, and AJ is Jewish. On her own initiative, she included notations about what she was

doing on each of these Easter weekends. The notations have been abbreviated and edited for confidentiality.

Two years later, and again without forewarning, we asked AJ to write down the dates for Easter and notations of personal events. Again in less than ten minutes, she produced another table, this time with every Easter date correct and with similar notations about personal events. After she had completed the second table, she was shown the one she had done two years before. She immediately pointed out the one incorrect date from two years before (April 17, 1987 should be April 19, 1987). We reviewed the notations to compare and there was perfect reliability. For example, in 2005 for 1981, she wrote only 10th grade. When asked if she was dating anyone, she elaborated on her new boyfriend, providing his name. In 2005, she provided us with a box of her diaries from 1986–1989. We found the entries for Easter Sunday for those four years and compared them to the notations she had produced that day and two years before. Every one of the notations she had made for the four Easter Sundays matched with what she had written in her diary for that day.

There was high reliability to AJ’s recollections. She provided the same events to the same dates and there was no instance where she provided different responses. We were able to verify the accuracy of her memory when she was asked, without forewarning, in May 2003 the dates of previous

Table 1. AJ’s recollections of every Easter from 1980–2003, produced November 21, 2003

AJ’s unexpected recall of all Easters since 1980. Next to each day, she also wrote a personal event for that day. This list was produced within 10 minutes. There is one error and it is off by two days. We have not found anyone who can find the error without resorting to a printed calendar. Nor have we found anyone who can produce this list of dates.

Date	Personal entry
April 6, 1980	9th Grade-Easter vacation ends
April 19, 1981	10th Grade-new boyfriend, H
April 11, 1982	11th Grade, Grandparents visiting for Passover
April 3, 1983	12th Grade, just had second nose reconstruction
April 22, 1984	Freshman at (school), Cs (friend) parents visiting
April 7, 1985	Just returned from a week in AZ, sick as a dog
March 30, 1986	Parents in Palm Springs, W, G, A (friends) staying at house
April 17, 1987	B (friend) for Easter, vomit up carrots
April 3, 1988	personal
March 26, 1989	Bs (friend) for Easter
April 15, 1990	make cookies, S breaks up with me next day
March 31, 1991	R (friend) visiting, gets carded for cigs
April 19, 1992	Easter Dinner at ... T(friend) comes over
April 11, 1993	hang all day, spaghetti dinner with R
April 3, 1994	wake up at H’s house
April 16, 1995	rainy day, brunch with H (friend)
April 7, 1996	personal
March 30, 1997	dinner with J and C (friends)
April 12, 1998	house smells like ham, M (friend) over
April 4, 1999	hang, describes specific event at work
April 23, 2000	Las Vegas for weekend
April 15, 2001	personal
March 31, 2002	hang
April 20, 2003	hang with J (husband) and family

meetings with us. Without hesitation, she told us: “June 24, 2000 ... July 8, 2000 ... July 15, 2000 ... July 23, 2000 ... August 19, 2000 (saying this was just before JLM left for a trip to Germany, which only she recalled), ... each date being correct. None of us was able to recall this list and it was absolutely accurate.

Memory for Public Events and Dates

We quizzed AJ from a book of dates and significant world events (Lucas, 2000), on several occasions and on one occasion, on video. She was able to recall an event when given a date, and a date when given an event, if the questions were within her areas of interest and the period of her good memory (approximately 14 years old and onward). Some examples of her recollective abilities are illustrated in Table 2. Again, the reader is reminded that she was never forewarned about what dates or events she would be questioned.

AJ's Mental Calendar

AJ has a highly developed knowledge of dates, knowing years that repeat and leap years. She can produce what day of

the week a particular date fell on if it falls within her memorized mental calendar. She readily admits she has trouble with dates outside her calendar span. When asked what day of the week was April 3, 1955 she told us she didn't know, as she couldn't “see it.” She spent several minutes trying to figure this out but was uncertain of the answer.

When given a date within her mental calendar, she says “I see it. I don't see the whole day at one time. I get to a portion of the day so I can see what day it was and whatever sticks out in my mind.” She places herself in the day or event and associates to it. She reports that her facility with dates starts around 1974, when she was eight, strengthens around 1978 when she is 12 and was phenomenally accurate from 1980 on when she was fourteen. She enjoys dates, dating events and going over them in her mind. AJ talks about dates in terms consistent with the mental calendar as being part of her semantic memory. When asked about her knowledge of dates she says “I just know it.” She says she has no idea how her knowledge of dates developed. All she can tell us is “I have always been about dates. I just know these things.” This quality of knowing is characteristic of information in semantic memory (Tulving, 1983, p. 49).

Table 2. Examples of AJ's excellent memory for events and dates if within her areas and time period of interest. Answers given below so reader can self-test

Name the day of the week and the significant event on this date

August 16, 1977; June 6, 1978; May 25, 1979; November 4, 1979 (book wrong date, AJ correct); May 18, 1980; October 5, 1983; January 17, 1994; December 21, 1988; May 3, 1991; May 4, 2001

Name the date for the event

Plane crash in San Diego? Who shot JR episode? Persian Gulf War begins?
Rodney King beating? OJ Simpson verdict? Bombing at Atlanta Olympics?
Death of Princess Diana? Concorde Crash? Election dates for G.W. Bush and Clinton?

Answers (events) AJ gave to dates:

8/16/77 – Tuesday, Elvis died
6/6/78 – Proposition 13 passed in CA
5/25/79 – plane crash, Chicago
11/4/79 – Iranian invasion of US Embassy
5/18/80 – Sunday, Mt. St Helens erupted
10/5/83 – Wednesday, bombing in Beirut, killed 300
1/17/94 – Monday, Northridge earthquake
12/21/88 – Lockerby plane crash
5/3/91 – last episode of Dallas
5/4/01 – Robert Blake's wife killed

Answers (dates) A.J. gave to events:

San Diego crash – September 25, 1978
JR – November 21, 1980
Gulf War – Wednesday, January 16, 1991
Rodney King beating – March 3, 1991
OJ Simpson verdict – Tuesday, October 3, 1995
Atlanta bombing – July 26, 1996
Princess Diana – August 30 or 31, 1997 (depending on France or US)
Concorde – July 25, 2000
Elections date – G.W. Bush – November 7, 2000, Clinton Nov 3, 1992 and November 5, 1996.

On four occasions we asked AJ to draw her mental calendars and she drew virtually the same calendars each time and in the same way. She drew one for years and another for months. Her calendar for years was drawn from left to right and at 1970 changed orientation from top to bottom. She told us her demarcation of years is based on her internal schema that she cannot explain. She said "this is how I see it. 1965 is when I was born. 1963 is when everything changed for the world ... I am interested in all that even though I wasn't born yet. 1965 is when I was born. 1960 I feel that with President Kennedy the world changed, and these are significant things the way I see my own life. 1974 is when we moved to California." She had no idea why she turned at 1970 and simply repeated this was the way she saw it, the way she had always seen it.

For months she first drew January in the 11 o'clock position, then counterclockwise filled in the rest of the months. She has no idea why she drew the months this way but insisted again it was how she saw it and always had.

Observations on AJ's Memory Weaknesses

In contrast to AJ's strong autobiographical memory, and her ability to recall dates and events, she is not a gifted memorizer. For example, she told us she has five keys on her keyring and can never recall which key is for what. She says she has to make lists to help her remember. She reports always having a terrible time with rote memorization for things such as learning history dates and poetry. Although she describes her mind like having a movie running, she is not recording her world verbatim in its totality. One day after several hours together, she was asked to close her eyes and tell what her two interviewers were wearing. She was unable to do so.

After making a videotape of AJ, we brought her back a month later and, without warning, interviewed her about specific events from the month before. When we asked her specific questions such as, had she talked about her second grade teacher, or had she talked about the date April 27, 1994, she told us she did not recall. We devised a recognition test to see if recognition would be better than free recall. She was asked about dates and events that had been covered during the video (targets) mixed with ones that had not been discussed on the video but had been at another time (distractors). She was very uncertain when answering questions on the recognition test and had to be prompted to answer. She only recognized one of four target dates and she mistakenly thought that three of the distractor dates might have been discussed on that date. She had similar difficulty recognizing which events had been discussed on the video. How paradoxical that someone with such a powerful autobiographical memory, and extraordinary ability to recall dates and events, was unable to recall or recognize the details of a videotaping from the month before. Her autobiographical memory, while incredible, is also selective and even ordinary in some respects. The neuropsychological test data reported next also demonstrate AJ's strengths and weaknesses in different forms of

memory, adding more evidence for the selectivity in her superior memory.

Neuropsychological Test Results

Global Test Performance

Information about AJ's general intellectual functioning, global memory and lateralization is presented in Table 3. Scores for Full Scale, Verbal and Performance Intellectual Quotient (IQ) are in the normal range. Her general memory index on the WMS-R is 122, 29 points above her Full Scale IQ and one and a half standard deviations above average. Traditionally the amnesic syndrome has been characterized by a 15 to 20 decrement between general memory and IQ, with the latter being in the normal range. These results document AJ's memory superiority on standardized tests.

The reader is reminded that neuropsychological tests of memory are designed to measure impairments, not superior memory. There can be ceiling effects due to limited capacity to measure high levels of performance. On a number of memory tests, AJ obtained the maximum possible score and those are indicated.

Anomalous Brain Lateralization

Anomalies in brain lateralization are characteristic of many neurodevelopmental disorders (Bradshaw and Sheppard, 2000). Although AJ insists she is right-handed and was entirely right-dominant on the Edinburgh Handedness Inventory, there were indications that she has anomalous lateralization (see Table 3). In a photograph of her at two years, eleven months of age, she is shown using her left hand to hammer a toy. She turned pages with her left hand during her neuropsychological examination. She worked from left to right on neuropsychological tasks that a normal right-dominant

Table 3. Memory index superiority to intelligence measures and lateralization

Wechsler Adult Intelligence Scale-Revised:	
Full Scale IQ = 93, Verbal IQ = 96, Performance IQ = 91, all average range	
Wechsler Memory Scale – Revised	
General Memory Index = 122, 1.5 sd above average	
General Memory Index vs Full Scale IQ	
Memory Index is 29 points above Full Scale IQ (note amnesic patients are defined by a Memory Index 20 points below IQ)	
Atypical Lateralization:	
Entirely right dominant on Edinburgh handedness inventory	
Brought picture of her at 2 years, 11 months using left hand	
During BNT, turned pages on test with left hand	
Worked right to left on several tasks, CFT, Trails	
One relative, brother, left-handed	
Mental calendars go right to left	

person works right to left. She drew the CFT right to left. Her mental calendars all go from right to left or counter-clockwise. Motor speed in her right hand was slower than her left hand, as well as being 1.6 standard deviations below average.

Atypical Variability in Neuropsychological Test Scores

One of the main areas of disparity in the scores, described previously, is AJ's significantly higher General Memory Index relative to her overall IQ. However, in spite of her superiority on certain memory tasks, she had impaired performance on tests of executive functioning, language and tests of memory that require the subject to organize the to-be-remembered material, as well as memory for faces. Moreover, she had normal performance on many other neurocognitive domains. The data are presented accordingly so the reader can consider her strengths, deficits and normal performance. This pattern of scatter among test scores is clinically significant and provides objective evidence of AJ's atypical brain functioning, beyond memory.

Areas of Strength on Neuropsychological Tests

In Table 4, neuropsychological strengths are identified as performance more than 1.5 standard deviations above average. AJ's strengths in memory are evident on certain tests. To orient the reader who may not be familiar with the particular tests, AJ's memory superiority is seen on tests of episodic memory, particularly when she is provided with some degree of structure in the material at encoding and/or at retrieval. Take for example the visual paired-associates test on the WMS-R where the subject sees six meaningless symbols

each paired with a different color. After a single study trial of these six pairs, AJ correctly selected the color that matched each of the six symbols and retained this over a 20-minute delay. In addition, she obtained a perfect score on the Warrington Word Recognition where she studied 50 words and then was asked to select the studied words from pairs of words, one being a studied word and the other a new word. Yet, as will be described shortly, her performance on the Warrington Face Recognition test was impaired. Her extraordinary autobiographical memory was supported on standardized testing with her perfect score on the Autobiographical Memory Test (AMT).

Strong attention was measured by both her excellent performance on Digit Span and on the Attention/Concentration Index of the WMS-R. The perfect performance on the Smell Identification Test supports her statements about sensitive olfactory functions. The Sensory-Perceptual Exam did not uncover any problems in those domains.

Areas of Weaknesses on Neuropsychological Tests

Deficit performance was defined as a score more than 1.5 standard deviations below average and results are presented in Table 5. Her deficits are observed on tests of executive functioning and reasoning, anterior left hemisphere functions, organizationally demanding memory tests and memory for faces.

The areas where AJ is showing difficulty include executive functioning, a term often used to mean frontal lobe functioning (Stuss and Levine, 2002), and even more specifically prefrontal (Miller and Cohen, 2001). Deficits of executive function were observed on one of the classic tests of frontal lobe functioning, the Wisconsin Card Sorting Test (Stuss

Table 4. AJ's strengths on neuropsychological tests

Strengths: Defined as performance more than 1.5 sd above average or perfect			
	Raw Score	Z-score	Comment
Memory Tests			
General Memory Index on WMS-R	122	1.5	near ceiling
Visual Memory Index on WMS-R	128	1.9	near ceiling
Visual Paired Associates on WMS-R			
Immediate Test	18/18		perfect
Delayed Test	8/8		perfect
Word Recognition, Warrington Test	50/50		perfect
Word Recognition from CVLT	16/16		perfect
Autobiographical Memory from AMT	27/27		perfect
Personal Semantic Memory from AMT	63/63		perfect
Attention and Working Memory Tests			
Digit Span subtest of WAIS-R	15	1.67	near ceiling
Attn/Concentration Index on WMS-R	122	1.5	near ceiling
Face Perception			
Face Perception on Benton Face Test	27/27		perfect
Olfactory Functions			
Smell Identification Test	40/40		perfect
Sensory-Perceptual Exam			perfect

Table 5. AJ's deficits on neuropsychological tests

Deficits: Defined as performance more than 1.5 sd above/below average			
	Raw Score	Z-score	Comment
Executive Function and Reasoning Tests			
Concept Formation and Shifting from WCST			
Perseverative Responses	38	<2.0	impaired
Executive Functions from HCT	78 errors	-2.3	impaired
Analogical Reasoning from WAIS-R	5	-1.67	impaired
Anterior Left Hemisphere Tests			
Motor Speed, Right Dominant Hand	36.5	-1.6	impaired
Dysnomia from Boston Naming	51/60	-2.7	impaired
Organizationally-Demanding Memory Tests			
Recall of Word-List from CVLT		>-2.0	impaired
Recall of Complex Figure, both delays	13/36 & 11.5/36		impaired
Face Memory Test			
Face Recognition, Warrington Test	38/50	-1.6	impaired

et al., 2000). AJ had a strong tendency to perseverate, a sign of abnormal functioning of the dorsolateral prefrontal cortex (Milner, 1963). She had great difficulty on the Halstead Category Test, a widely used neuropsychological test of abstraction and concept formation, although its sensitivity to specific brain regions has not been established (Demakis, 2004). As was the case for Luria's S, AJ was not strong in analogical reasoning as seen in her low score on the Similarities subtest of the WAIS-R. There was a notable tendency towards concrete versus abstract answers.

Two neuropsychological scores point to possible deficits in the anterior left hemisphere, namely, slowed motor speed with the right "dominant" hand and naming problems (dysnomia) on the Boston Naming Test (Lezak, 1995) where she made semantic paraphasias, calling dominoes "dice", a latch "lock", a scroll "declaration", tongs "clampers", a sphinx "pharaoh statue", a palette "paint", and an abacus "Chinese checkers." Her trouble producing specific words was also observed in her spontaneous speech. She often has trouble providing linguistically precise responses to specific questions.

The deficits in specific memory tests are particularly interesting. Her performance was significantly impaired on word-list recall as measured by the California Verbal Learning Test. Impaired performance such as hers has been described in patients with frontal lobe-based memory impairments, particularly those with damage to the left posterior dorsolateral regions (Alexander *et al.*, 2003). In this test, the subject studies a list of 16 words belonging to four semantic categories (fruits, articles of clothing, tools and spices) with four words from each category. Her recall was poor under free and cued conditions as well as at short and long delay. She used serial clustering over semantic clustering, a much less effective strategy for recall. Recall from the end of the list was poor and she had significantly more perseverations, that is, repeated words during recall, than average. Nevertheless her delayed recognition performance was perfect, with no false alarms. Although the CVLT is a "memory" test, the recall

portion requires a great deal of organization on the part of the subject so that the material is encoded in a way that makes it accessible for retrieval without external cues as is the case with free recall. When cues are re-presented in the recognition portion, the subject's reliance on organization and internal cues is reduced.

Difficulty with memory for subject-organized material was in the visual domain as well as the verbal. Her recall of the Complex Figure Test was below average both for immediate and delayed recall. This test requires the subject to use their own strategies to copy a complex figure, which they then draw without cueing immediately after the copy trial and with delay. There was significant loss of detail in AJ's recall, a qualitative signal of left hemisphere dysfunction (Lezak, 1995, p. 478). Her poor recall on the CFT was not due to a global deficit in visual memory as her Visual Memory Index on the WMS-R was superior and her performance on Visual-Paired associates from the WMS-R was perfect (see Table 4).

Performance on the Face Recognition Test was markedly impaired. In this test, the subject is shown a set of 50 unfamiliar faces at study and at test is asked to pick the face just studied from 50 pairs of faces where one is the target face and the other a new face. AJ kept saying that neither face was familiar and thought she was being shown two completely new faces. In view of her very good performance on the face perception test (Benton Face Perception Test), her impairment is specific to facial memory. Disorders of visual recognition of faces can reflect neuropsychological deficits associated with right hemisphere lesions (Hécaen and Albert, 1978); however, research with fMRI found face recognition positively correlated with left parietal and left medial frontal/anterior cingulate cortex (Leube *et al.*, 2003).

Areas of Normal Performance on Neuropsychological Tests

The normal areas of her test performance are listed in Table 6. Her normal Verbal Memory on the WMS-R contrasts with

Table 6. Other neuropsychological domains in normal range (within 1.5 sd)

Domain	Test	Score
Memory Tests	WMS-R Verbal Memory	Z = 0.93
	WMS-R Delayed Recall	Z = 1.0
Semantic Memory	WAIS-R Information	Z = 0.0
Executive Functions	Written Fluency	Z = -0.6
	Oral Fluency: Letters	Z = -0.3
	Oral Fluency: Category	Z = +1.3
	Ruff Figural Fluency	Z = -0.8
	Trails A	Z = -0.6
	Trails B	Z = +0.5
	Stoelting Stroop Test	Z = +0.5
	Grooved Peg, Right	Z = -0.6
Manual Dexterity	Left	Z = +0.1
	Finger Tapping, Left	Z = 0.0
Motor Speed	Reading Level	Z = +0.2
Language	Spelling Level	Z = +0.7
	Vocabulary	Z = 0.0
	Comprehension	Z = -0.33
	Picture Completion	Z = -1.33
	Picture Arrangement	Z = 0.33
	Block Design	Z = -0.33
	Object Assembly	Z = -1.3
	Rey-O CFT Copy	35/36
Calculations	Hooper Visual Organization	Z = +0.2
	Arithmetic Level	Z = -0.6 eighth grade
Visual-motor	Arithmetic	Z = 0.0
	Digit Symbol	Z = 0.33
	Symbol Search	Z = +1.0
Mood: Beck Depression Inventory		never in depressed range

her superior Visual Memory Index (see Table 4) supporting her claims of vivid visual recollections. Semantic memory as measured by the Information subtest of the WAIS-R is entirely average, and measures an individual's acquired knowledge of common facts. The measures of executive function on which she performs in the normal range listed on Table 6 differ from those areas of executive functioning where she exhibits impairments listed on Table 5. The tests on which she is impaired are unstructured and require considerable abstraction, hypothesis formulation and conceptual shifting. The tests on which she is normal are tests of fluency, processing speed and novelty, particularly Trails A and the Stroop Test. Other areas of normal performance indicate that she has developed average reading, spelling, and arithmetic skills, despite her complaints of difficulties in school. Her level of self-reported depression on the Beck Depression Inventory was measured on multiple occasions and was never in the clinically significant range.

AJ Compared to Two Mnemonists, S and VP

To compare AJ to Luria's case S (1987), we asked her to learn a 4×13 matrix of numbers. After studying such a matrix for three minutes, S was able to call off all 52 numbers

in succession in 40 seconds. When AJ was handed a matrix to learn, she laughed, saying it was impossible. After studying the matrix for 3 min 52 sec, she then tried to recall on a blank piece of paper. She was able to recall 7 of the 52 numbers, 5 from the first column and the bottom right number.

VP was able to recall Bartlett's tale "The War of the Ghosts" with considerable detail after reading it through twice, and counting backwards by sevens from 253 to 0 (Hunt and Love, 1972). When AJ was asked to read through the story and try to remember it, she again said "No way." After counting backwards, she recalled 7/49 nouns and 8/68 verbs. VP's score at one hour after he had studied the story was 33/49 nouns and 40/68 verbs, and he had a similarly high score six weeks later. The story is difficult to remember because of its lack of meaning. AJ's comment about it was "That is the stupidest story I've ever read."

Discussion

AJ has led us into new, unexpected terrain as we explored what we believe to be the first reported case of a person with this form of superior autobiographical memory. She displays phenomenal interest and delight in recalling her personal

past. Her recollections were highly reliable and accurate where verification was possible. She obtained a perfect score on the Autobiographical Memory Test. We have documented her claim that, when given a date, she can go back to that date through the years, particularly from age 14 to the present, and recall what she was doing on that date. Her recollections are fast, seemingly automatic as she claims. Data include AJ's self-reports, our observations, documentation of her memory with novel testing procedures developed specifically for AJ, and standardized neuropsychological testing. Each approach revealed different but complementary information that, taken together, offers a profile of her phenomenal memory in the context of other neuropsychological functions and how it impacts her life. The following discussion weaves threads from these typically separate approaches to offer the reader hypotheses about AJ's form of extraordinary memory.

First, it is important to address what several of our colleagues have suggested, namely, that AJ is simply pulling the wool over our eyes and in fact there is nothing particularly remarkable about her memory. How do we know that she isn't rehearsing, practicing, and preparing in order to fool us into believing her memory is extraordinary? The reader is reminded that AJ never knew in advance the hundreds of dates and events she was going to be asked by us, so she would not know what to prepare. She had no idea we were going to ask her about Easters from 1980 on before she was asked to write them down. Nor did she know two years later that she would be asked to do the same thing again, which she did entirely accurately again and reliably. When she brought a box with four years of her diaries, she had no idea which of the 1,460 days we would be verifying. When we queried her from the book of news events (Lucas, 2000), often we did not know in advance which dates we were going to select. It is also noteworthy that AJ herself told us what she could and could not recall. Dates and events before 1980 but within her lifespan were "fuzzy" but from 1980 on were "crystal clear." She could recall public events only if she was interested in them, or if something important had happened to her on the day they occurred. She told us what she could accurately remember and what she did not remember. She repeatedly told us she was "a terrible memorizer." Her difficulties with some types of remembering have been described on formal tests such as the CVLT. Her neuropsychological testing provided no evidence of malingering or invalid performance and she did have supernormal scores on a subset of standard memory tests. If anyone can tell us how such a profile could be "faked" and why, our position about the validity of AJ's presentation is open to modification.

We know of no other reported case of someone who recalls personal memories over and over again, who is both the warden and the prisoner of her memories, as AJ reports. We took seriously what she told us about her memory. She is dominated by her constant, uncontrollable remembering, finds her remembering both soothing and burdensome, thinks about the past "all the time," lives as if she has in her mind "a running movie that never stops" and has memories tied

closely with dates. We relied on her own reports when it came to describing her awareness of her memory and the meaning of her memory to her life, as there are no objective tests to measure this. Whereas previously reported cases of superior memory have been described, they are of individuals who are capable of encoding and reciting prodigious amounts of new information, using practiced mnemonic strategies (Hunt and Love, 1972; Luria, 1987; Gordon *et al.*, 1984; Thompson *et al.*, 1991; Wilding and Valentine, 1997; Maguire *et al.*, 2003; Ericsson *et al.*, 2004).

One way to conceptualize this phenomenon is to see AJ as someone who spends a great deal of time remembering her past and who cannot help but be stimulated by retrieval cues. Normally people do not dwell on their past but they are oriented to the present, the here and now. Yet AJ is bound by recollections of her past. As we have described, recollection of one event from her past links to another and another, with one memory cueing the retrieval of another in a seemingly "unstoppable" manner. According to one theory, it takes a special neurocognitive state to enable present stimuli to be interpreted as such cues. Such a state is called episodic retrieval mode and refers to the orientation of the subject as she focuses on past happenings (Tulving 1983, 1999). Studies using positron emission tomography have identified regions in the right and left prefrontal cortex and anterior cingulate gyrus that are activated with the maintenance of episodic retrieval mode (Lepage *et al.*, 2000). AJ seems unable to turn off episodic retrieval mode as in normal individuals. She has trouble inhibiting her constant remembering of her personal past at will. Inhibition is an important cognitive function that has been associated with the right inferior frontal cortex based on human lesion-mapping, leading to speculation the same regions may be important for memory retrieval (Aron *et al.*, 2000).

This view of AJ is not sufficient to capture fully the nature of her unique remembering. While she does spend a great deal of time remembering from her personal past, as do some older people, there is another remarkable feature which is her rich repertoire of personal memories that is available and accessible to her. It is quite possible for someone to be in a state of remembering one's personal past without vivid, specific recollections as to what one was doing on a particular date. Like us all, AJ has a rich storehouse of memories latent, awaiting the right cues to invigorate them. The memories are there, seemingly dormant, until the right cue brings them to life. But unlike AJ, most of us would not be able to retrieve what we were doing five years ago from this date. Given a date, AJ somehow goes to the day, then what she was doing, then what she was doing next, and left to her own style of recalling, what she was doing next. Give her an opportunity to recall one event and there is a spreading activation of recollection from one island of memory to the next. Her retrieval mode is open, and her recollections are vast and specific. There has been research on brain regions involved with episodic retrieval mode, but not on superabundant autobiographical memory as it has not been identified before.

We propose that AJ's form of autobiographical memory syndrome warrants its own definition and terminology. We suggest calling it the *hyperthymestic syndrome*, based on the Greek word *thymesis* which means "remembering," and *hyper* meaning "more than normal." The two defining features of hyperthymesia are: 1) the person spends an abnormally large amount of time thinking about his or her personal past, and 2) the person has an extraordinary capacity to recall specific events from their personal past. Thus hyperthymesia differs from superior memory which refers to the supranormal ability to acquire and recall new information but not autobiographical information. We have avoided the term *hypermnnesia* as this term has its own specific definition in the field of experimental psychology and refers to an increase in recall over repeated tests in the laboratory (for review see Erdelye, 1996).

Why it is that AJ has extraordinarily good memory for some things and not for others is indeed interesting. Although she can quickly, reliably and accurately tell what she was doing on a given date, she had trouble recalling specific events from a videotaping the month before. This does demonstrate that her memory is selective, and as seen on some standard memory tests her memory performance ranges from perfect to below average.

There are indications from AJ's neuropsychological test results, as well as her self-reports, that her hyperthymestic syndrome may be related to and possibly caused by poor executive functions in the areas of abstraction, reflection, and inhibition. Her vulnerability to dwelling on her personal past, recalling memories over and over, may reflect a form of disinhibition such that she lacks the normal capacity to switch memories off. Her rich storehouse of memories may have developed because of her use of concrete, highly structured encoding and retrieval processes, one of which is the calendar as will be discussed further.

Neuropsychological tests documented that AJ, while of average intelligence, has significant deficits in executive functions involving abstraction, self-generated organization and mental control. Many researchers agree that the broad term "executive control" is the function of the prefrontal cortex (for review see Miller and Cohen, 2001). She had difficulty with tasks that required her to formulate her own organization on new information (WCST, HCT, CVLT, CFT) but was superior on tasks that had built in organization (e.g., Visual Paired-Associates, Word Recognition). She has difficulty with analogical reasoning giving concrete versus abstract responses (e.g., Similarities). She had significant deficits on the CVLT, a memory task that depends on executive functions, strategy formulation, and inhibition of competing recollection and is particularly impaired in patients with left-posterior frontal lobe lesions (Alexander *et al.*, 2003). Face recognition has been associated with left medial frontal/anterior cingulate (BA 32/9) cortex (Leube *et al.*, 2003). Other indications of atypical frontal lobe functions are her dysnomia, anomalous lateralization, and obsessive-compulsive tendencies.

AJ may have a variant of a neurodevelopmental, frontostriatal disorder putting her at risk for her *hyperthymestic syndrome*. Deficits in executive functioning and anomalous lateralization are both found in neurodevelopmental frontostriatal disorders which include autism, obsessive-compulsive disorder (OCD), attention deficit hyperactivity disorder, Tourette's syndrome and schizophrenia (Bradshaw and Sheppard, 2000). The frontostriatal system (dorsolateral prefrontal cortex, lateral orbitofrontal cortex, cingulate, supplementary motor area and associated basal ganglia structures) is vulnerable to neurodevelopmental disorders and this is consistent with AJ's history and presentation. For example, AJ reports that from an early age she became upset when order in her external environment was disturbed, a sign of early obsessive-compulsive tendencies. There are signs of atypical developmental features before she started to write diaries at the age of ten and become aware of her detailed memory around the age of twelve and a half, in 1978. With the exception of some autistic savants (O'Conner and Hermalin, 1989), superior memory abilities are not characteristic of neurodevelopmental fronto-striatal disorders. And although AJ is not autistic, nor do savants remember autobiographical information, there are certain similarities between them. Like autistic savants, AJ had an interest in dates from an early age, has strong domain-specific areas of knowledge, has repetitive and obsessive tendencies (Heavey *et al.*, 1999) and has a highly variable neuropsychological profile with areas of superiority co-existing with areas of deficit (Winner, 2000). We suggest that it might be fruitful to examine frontostriatal symptoms in other cases of superior memory, as they too may have deficits in executive functions associated with their unusual memory abilities.

The hypothesis that AJ's superior memory may be caused by atypical neurodevelopment is based on her unusual profile of performance on neuropsychological tests taken in conjunction with hints from published research. It is, however, quite possible that there is no causal relationship and that the overall parallels between her memory and her neuropsychological weaknesses are simply correlative. Since there are no previous studies of superior rememberers that have simultaneously examined neurocognitive domains outside memory, particularly frontal lobe functions, there are no comparative data at this point. The findings from AJ are sufficiently compelling to warrant further exploration of the relationships among forms of superior memory and other cognitive domains in future research.

AJ's highly developed mental calendar provides her with a structured, concrete framework to encode and retrieve information. It should be noted, however, while dates are linked to her memories, they are not the only retrieval cues for personal recollections. We have described how she can recall dates when given an event, and she can recall events when given a date. Her recollection of dates and public events was verified from independent sources. Her recollection of personal events was verified where possible with her diaries. When given a date, she can tell you what day of the week it fell on. She told us she places herself in the date, recalling where she was and what she was doing on it. When given the

same date on different occasions, she reliably told us the same story as to what she recalls doing on that day.

Her mental calendar and tendency to encode and retrieve information by dates can be viewed as a mnemonic strategy; however, unlike previously reported cases of superior memory, AJ does not consciously rehearse the use of dates to facilitate her memory, nor is she able to apply this or any strategy to learn new information such as word lists. However, she does rehearse dates, but she says this occurs automatically and obsessively. Her calendar can be thought of as a mnemonic that has become automatized with extensive use. It is particularly interesting that AJ uses dates to organize her memories as dates are typically very poor recall cues in laboratory studies of normal subjects and days of the week are poorly remembered (see Friedman, 1993).

AJ is not a calendrical calculator, the rare ability found in people with autism who provide dates based on calculation rather than memory (Heavey *et al.*, 1999). For example, Horwitz *et al.* (1965) describe a calendrical calculator who could provide the day of the week of a given date for a span of some 40,000 years. AJ's knowledge of dates is constrained to a period linked to her personal experience. It is, we suggest, part of her semantic memory, providing a structured but somewhat inflexible context for encoding and retrieving personal experiences. She told us over and over that dates are things she "knows," and that sense of knowing characterizes retrieval from semantic memory. The retrieval of a date can then produce retrieval of personal experiences from episodic memory, which is characterized by a sense of "remembering," exactly how she describes such memories (Tulving, 1983; Gardiner *et al.*, 2002).

Current theoretical accounts of autobiographical memory distinguish between memories for personal facts or personal knowledge and memories of specific personally experienced events that are accompanied by rich sensory-perceptual recollections with a special awareness of remembering. According to one theory, semantic autobiographical memory pertains to general knowledge of the self and episodic autobiographical memory pertains to recollections of a specific event with reexperiencing of contextual details and a sense of awareness of the self in one's past (Wheeler *et al.*, 1997). A similar distinction has been made between event-specific sensory and perceptual episodic memory and higher level knowledge of self that covers a larger time period (Conway, 2001). According to such theoretical distinctions, AJ's superiority seems particularly striking for semantic or general autobiographical memory. She has a developed self-knowledge particularly surrounding dates and she just "knows" these things. Moreover, her episodic recollections are relatively sparse. For example, she does dismally on word-list recall tasks which are heavily dependent on episodic memory. She was unable to recall the details of a video-taping episode from a month earlier, a clear episodic or event-specific recollection. Yet when shown the tape again, she was able to reproduce the same recollection when she heard the same question again. AJ's *hyperthymistic syndrome* may be a case of highly superior semantic autobiographical memory.

It is somewhat surprising that superior memory does not necessarily facilitate other aspects of everyday life, and in fact, in the case of AJ her memory was not helpful in school, and causes her to spend much of her time recollecting the past instead of orienting to the present and the future. Given the considerable emphasis placed today on techniques to facilitate memory skills, particularly with children, but also with aging adults, it may be worth questioning just what forms of superior memory benefit everyday functioning. Who would expect that VP, who could play seven simultaneous chess games blindfolded, and had an estimated IQ of 136, would be employed as a store clerk (Hunt and Love, 1972)? How paradoxical that Luria's case S, who could recall seemingly unlimited amounts of materials for years, had trouble capturing the meaning of what he read and moved from one job to another, eventually becoming a professional mnemonist. In addition, there was nothing consistently noteworthy about the occupations of the ten cases of superior memory reported by Wilding and Valentine (1997), although this was not a focus of their investigations. Occupations included a telephone operator, mathematician working in a financial institution, an airport cleaning supervisor, a journalist (the only female), business consultant, hypnotist/magician, student of English, nurse, memory improvement teacher and a 13-year-old too young to be employed.

Just how unique is AJ's memory, whether or not there are other cases of hyperthymesia out there in the world, and whether there are other forms of superior memory yet-to-be described, are questions that must await further research for answers. There is a large literature on patients with amnesic syndromes that has enriched our understanding of how memory can fail and the brain regions involved. By comparison, research on forms of superior memory is miniscule, leaving much to be explored. We suggest that work with AJ has demonstrated the importance of not only exploring her memory as she describes it, but also looking at memory in the broader context of other neuropsychological domains. Previous research on cases of superior memory have focused primarily on subjects' performance on laboratory memory tasks, but have yet to examine other neuropsychological functions in depth. Answers to questions about the relationships between superior memory and other neurocognitive functions can only be addressed by investigating these cases of superior memory in the broader context of other neuropsychological functions.

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