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Hyperlexia in 3-year-old twins with and without Autistic Spectrum Disorder

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Abstract

This article presents a case study on hyperlexia in a pair of non-identical twins of chronological age (CA) 3 years 9 months, with and without Autistic Spectrum Disorder (ASD). The aim is to provide a better understanding of the two types of hyperlexia by establishing their profiles using various sources of psycho-educational assessment reports. Results show a word recognition age (WRA) of 5 years 9 months for the ASD male and 8 years 11 months for the neurotypical female. With a verbal functioning estimated at 1 year 6 months, the male twin exhibited an unexpected level of ability that is advanced for his CA in not only literacy skills but in numeracy as well. His hyperlexia is considered a savant ability as his splinter skills are in significant disparity to his overall impairments. Unlike her brother, the female twin has a reading comprehension age (RCA) well above her CA, but her RCA is still lower than her WRA by more than 1.5 years.

Keywords: Word recognition, splinter skills, comprehension, Hyperlexia, Autistic Spectrum Disorder, Savant Syndrome

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INTRODUCTION

Hyperlexia had been initially noticed by clinicians (for e.g., Kanner, 1943; Parker, 1919; and Phillips, 1930) as an unexpected precocious reading ability in children with severe cognitive impairment (Ng, 2014). As a developmental condition, hyperlexia sparked researchers' interest in studying it as a savant ability (Grigorenko, Klin, and Volkmar, 2003). Savant idiosyncrasy has been described by Treffert (2010) as a paradox of genius and limitation in a person with incredible memory – a facility purportedly linked to genetic memory.

The incidence of developmental hyperlexia (see Ng, 2013) has been estimated to be between 5% and 20% (Grigorenko, Klin, and Pauls, 2002). For children with autism, the frequency of its co-occurrence is between 5% and 10% (Burd and Kerbeshian, 1985). In most learning disorders, there is a higher rate of incidence in boys as compared to girls for disorders related to the left or right brain. However, there is no evidence of significant gender differences in the occurrence of hyperlexia (Grigorenko, et al., 2002). The prognosis is that such a phenomenal word-calling ability may or may not continue to develop although word recognition skills remain well above expectations in comparison to other cognitive or linguistic abilities.

Viewed within the parameters of language per se, hyperlexia is commonly referred to as the discrepancy between children's advanced word recognition and poor comprehension. It became more of a focus of language research after the term hyperlexia was coined by Silberberg and Silberberg (1967). They used it to refer to the significantly higher ability to recognize words than either the evaluated verbal functioning level or ability to comprehend the material that was read. The single-subject study by Elliott and Needleman (1976) is a case in point - the subject with a total absence of speech could recognize words before age 2 and use sentence cards and even a typewriter to make known her needs. Gradually, the use of the term hyperlexia evolved to refer to the differential language development in not just children with severe cognitive impairment, but those with typical (e.g. Niensted, 1968; Treffert, 2010) and superior IQ (e.g. Jackson and Biemiller, 1985; Pennington, Johnson, and Welsh, 1987; Whitehouse and Harris, 1984) as well.

Outside the realms of a developmental condition, language impairment, echolalia and preoccupation with print material in brain-damaged children (e.g. Mehegan, Fritz, and Dreifuss, 1972) and adults (e.g. Suzuki, Itoh, Hayashi, Kouno, and Takeda, 2009) have been described as symptoms of an acquired form of hyperlexia in research literature. In addition, unexpected splinter skill(s) such as acquired hyperlexia arising from brain damage has been described by Treffert (2010) as the accidental genius or acquired savant syndrome. It is a rare condition and sometimes more than one splinter skill is developed because of the brain damage. In a case of multiple talents in hyperlexia, Patti and Lupinetti (1993) reported on a young woman with autism and hyperlexia who

exhibited several other exceptional abilities as well, including memory for large numbers and dates. Her hyperlexia is described as a savant ability since her splinter skills were in significant disparity to her overall handicaps. The developmental form of hyperlexia can be differentiated from the acquired form by the early reading, which can take parents by surprise. Unsurprisingly, clinicians such as Pennington et al., (1987) have called hyperlexia an unexpected reading precocity.

As the compulsion to decode print stimuli without comprehension of its meaning is symptomatic of hyperlexia (Whitehouse and Harris, 1984), the precocious reading ability has been likened to barking at print and marked by echolalia. However, case studies by Aram and Healy (1988) identified 2 subtypes of hyperlexia in children, showing that they were not merely barking at print. Superior phonetic analysis was one subtype, and superior visual analysis was the other. Richman and Wood (2002) reported that these two subtypes could be traced to the different neuro-maturational etiologies for the trait of good word-recognition. The first is linked to difficulties in using right hemisphere brain processing for visual memory, hence the good reading can be attributed to strengths in the left hemisphere for phonemic processing. The brain hemisphere weaknesses and strengths are reversed for the latter subtype. On the other hand, Nation (1999) had put forth that hyperlexia should be seen as part of the normal variation in reading skills which involves differences in individuals in terms of their orthographic, phonological and semantic processing, print exposure, and short-term memory.

The labelling of comprehension impairment in hyperlexia is not as straightforward. According to Riès, Dronkers, and Knight (2016), language is reportedly one of the most lateralized human brain functions, and left hemisphere dominance for language has been reliably confirmed in both experimental and clinical settings. Therefore, the comprehension impairment in hyperlexia can be linked to a weakness in left hemisphere language processing. Based on the comprehension impairment, efforts had been made to use it to revamp the definition of hyperlexia and the "idiot savant" reference from the early days. Most notably, Healy (1982a) called hyperlexia an "enigma" instead. She also took issue with the inclusion of those with no comprehension impairment in hyperlexia. Using clinical studies as the basis, she specified symptoms, such as a spontaneous ability to read before age 5, difficulty with language processing in both listening and reading modes, an impairment of expressive language and a compulsive preoccupation with reading together with echolalia - the repeating of speech sounds, for hyperlexia. Such narrowing of benchmarks for hyperlexia have been challenged, though.

In challenging the assumption that there has to be a co-occurrence impaired comprehension in hyperlexia, Temple and Carney (1996) presented a sample of girls with Turner's syndrome and hyperlexia who had matching levels of comprehension and single word reading. Other diagnostic symptoms of hyperlexia have similarly been found. For instance, Siegel (1984) presented a case of a female child with autism and hyperlexia manifesting motor-visual skills that are severely impaired. Contrastingly, cases

of children with hyperlexia showing exceptional ability to discriminate visual patterns have been presented as well (see Cobrinik, 1974; Tirosh and Canby, 1993; Whitehouse and Harris, 1984). The heterogeneity in the phenotype of developmental hyperlexia as an exceptional word-reading ability would render it as a syndrome in the context of disordered language development. Indeed, Grigorenko, Klin, and Volkmar (2003) had examined the dispute on whether hyperlexia is a distinct syndrome with comorbidities, given that it exists with several different disorders, or if it is a part of the spectrum of other disorders. They concluded with a rejection of the latter and rendered hyperlexia the status of a distinct syndrome.

Given that children with hyperlexia look normal and sound intelligent, people are likely to rule out the idea that children who can read print before preschool could be suffering from any language disorder. The assumption is that these children would eventually comprehend the meaning in the same way they easily figured out how to read the print. Their ability to read well ahead of their peers would usually give adults the impression that they are very intelligent. Indeed, there are researchers such as Elliott and Needleman (1976) who have taken a different perspective on hyperlexia and argued that it is a demonstration of a unique and enhanced cognitive ability, rather than a disorder. Unfortunately, facility with the words of the text does not necessarily promise improved comprehension (Fleisher, Jenkins and Pany, 1979). Hence, overlooking impairment in comprehension when it is masked by a child's hyperlexic tendencies can lead to a further widening of the discrepancy between word recognition and comprehension for the child.

It is therefore important to pay attention to language developmental milestones for children with hyperlexia, especially when there are no physical features on the children to mark it. Studies have shown that children with hyperlexia are unable to pass age-appropriate verbal and non-verbal Piagetian tasks (Healy, 1981; Huttenlocher and Huttenlocher 1973) - this signified their underlying cognitive deficits. To account for word recognition in cognitively disordered children, Goodman (1972) and Cain (1969) have reported that children with hyperlexia show symptoms of unusual memory for unrelated auditory and visual stimuli. Compulsive preoccupation with reading was also mentioned as a contributory factor. In a case of a compulsion to respond to print material described by Suzuki, Itoh, Hayashi, Kouno, and Takeda (2009) described as "visual groping" in a 69-year-old female patient with acquired hyperlexia and callosal disconnection syndrome, a focal lesion was the causal factor. She displayed symptoms of echolalia as well, in repeating words emanating from hospital announcements or from unrelated conversations around her. The two features were absent prior to her brain damage.

In the developmental hyperlexia case due to callosal syndrome or split-brain in Kim Peek (a.k.a. "Kimputer"), the savant who was the inspiration behind the movie *Rain Man*, he was said to have the Mount Everest of memory (Treffert, 2010). Imaging of his brain

show the absence of the entire corpus callosum, the large connecting tissue between the left and right hemisphere of the brain amongst other missing connecting structures. He could read and memorize books rapidly because he could read two pages at a time, one page with the left eye and the other with the right. Although his talent in reading and compulsive preoccupation with the activity is symptomatic of hyperlexia, he was also said by Treffert (2010) to be dyslexic as he could even read a page turned upside down or sideways. He was both a walking calculator and encyclopaedia - he could instantly calculate the sum and mean of a column of numbers in a telephone book and regurgitate with great fidelity, factual information of numerous areas of interest. Misrepresentations of information would not be tolerated by him - he had shouted for an actor in a Shakespearean play to stop when the actor missed some words in his line (Treffert, 2010).

According to Treffert (2010), autism was not the diagnosis for Kim but that of a developmental disorder not otherwise specified. Doctors had considered Kim to be a retard when he was nine months old, but his parents read to him a lot and by age eighteen months, he was able to memorise books read to him in a single sitting. However, he did not start walking until four years of age, and his problems with balance and hand-eye coordination continued through to his adulthood - he needed help to bathe and dress himself, brush his teeth and comb his hair. With more social exposure after the movie became a hit, he was no longer reclusive or awkward in social situations but became increasingly witty in conversations even, as his comprehension improved. His is a case in point which shows the plasticity of the brain in that it can rewire itself and even have the flexibility to even create - forming original and entirely new things other than producing literal memory recall only.

Various researchers (e.g., Huttenlocher and Huttenlocher, 1973; Mehegan, Fritz, and Dreifuss, 1972; Burd, Fisher, Knowlton, and Kerbeshian, 1987; Treffert, 2011) concur that the prognosis for hyperlexia is better than one without the phenomenal reading ability as reading is a tool for acquiring knowledge (see Ng, 2013). For the children with atypical development, researchers (Huttenlocher and Huttenlocher, 1973; Mehegan, Fritz, and Dreifuss, 1972) have reported a better lifelong outcome for them as compared to those without hyperlexia. A few studies (Burd, Fisher, Knowlton, and Kerbeshian, 1987; Burd, Kerbeshian, and Fisher, 1985) even reported markedly increased IQs for their samples of children with pervasive developmental disorders (PDD) and hyperlexia. According to Treffert (2011), the neurotypical group with their advanced reading at a very early age inevitably draws attention. Eventually their classmates catch up in reading skills, but they in having very bright minds usually, go on to have very typical, successful lives. He also noted that the autistic-like abnormalities in hyperlexia can be remediated through occupational and behaviour therapy.

Healy (1982b) has described the intense and preoccupying interest in print stimuli as a stereotypical behaviour for children with hyperlexia, and that the preoccupation replaces

other developmentally appropriate activities. To reduce such default repetitive behaviour which is self-stimulatory (“stimming behaviour”), occupational and behaviour therapy is recommended. Social skills training can also help as a lack of exposure to social activities can compound any difficulties in conforming to social rules in a group or classroom setting which typically developing children have no issues with. Social and communication deficits, if found together with the stimming behaviours in hyperlexia would imply that there is a co-occurrence of autism spectrum disorder (ASD), as the two traits can be identified under the criteria for ASD in the Diagnostic and Statistical Manual of Mental Disorders Fifth Edition (DSM-5) (American Psychiatric Association (APA), 2013). In DSM-5, the “triad of impairments” from the DSM-IV-TR (2000) has been reduced to two domains - one that has the two social and communication domain items in the earlier version combined, and the other is the domain of repetitive behaviour and interests which remains separate. In addition, a new trait of unusual sensory behaviours is included in the latter domain, and the specific age of onset is no longer included in the DSM-5 ASD diagnostic criteria.

With respect to the reference to hyperlexia as a savant syndrome based on the unexpected word reading precocity, developmental hyperlexia is different from other types of savant syndrome over time as there is a ceiling on word decoding ability (Heaton and Wallace, 2004). Therefore, the gap between the word reading age (WRA) and chronological age (CA) which starts off with a significant difference earlier in the development of the child with hyperlexia would narrow with the progression of time. As mentioned, the neurotypical peers would ultimately catch up on word decoding ability. Researchers (Siegel, 1984; Sparks, 2001; Whitehouse and Harris, 1984) have reported that the word recognition skill relative to measures of comprehension in hyperlexia would stagnate or decline over time. They attributed this to the lack of progress in word decoding skills or even a deterioration of it. Correspondingly, if the comprehension improves without a corresponding advance in word recognition, the significant difference between these two measures that defines hyperlexia would diminish.

To write more specific goals and objectives in a child’s Individualized Educational Program (IEP) based on the hyperlexia profile, a descriptive-based system (see Cupples, 2011) using a prescribed set of parameters such as language or reading is likely to give educators more information, than trying to determine the particular etiologic category (autism, SLI, etc.) for the affected child. According to the Simple View of Reading (Nation, 2019), the complexity in comprehension difficulties can be captured as the outcome of two groups of skills: decoding and reading comprehension. The variance in reading comprehension can be explained by the Simple View which provides a good framework to guide the classification of reading disorders. Using the Simple View where the concept of reading disability is modelled by the two components of decoding and comprehension, the child with hyperlexia can be profiled as a poor-comprehender (Ng, 2013). As dyslexia is characterized by word recognition difficulties with good comprehension in this model; hyperlexia would be considered as the polar opposite

since it is characterized by advanced word recognition with comprehension difficulties (Aaron, 1989; Gough and Tunmer, 1986).

According to Healy (1982a), children with hyperlexia in their pursuit of word-reading do it with a focus and intensity where they do not look for the meaning of what they read. She pointed out the likelihood that they were unable to code what they were reading into meaningful schemata. Hence, there is a lack of interaction with the content besides the printed words, which leads to the failure of storage and retrieval of meaning to occur at all for them. To target their deficit in the formation and organization of schemata for processing what they read, remediation by schematic scaffolding supports is recommended (Healy, 1982b).

Researchers (Deevy and Leonard, 2004; Goodwin, Fein, and Naigles, 2012; Hundert and van Delft, 2009; Schulz and Roeper, 2011) have reported that poor-comprehenders have difficulties coding text based on "Wh" questions which are the who/what/where/when interrogatives. In the study by Hundert and van Delft (2009), poor comprehenders' efficiency at answering questions was higher with visual than verbal scaffolding; but the absence of scaffolding would take the biggest toll on this efficiency. Based on the effectiveness of the Scaffolding Interrogatives Method (SIM), which employs a visual scaffolding of the schemata of "Wh" questions (see Ng, 2014 and Ng, 2016), it is recommended for the respective remediation in reading comprehension.

METHODOLOGY

This study used a convenience sampling with a single-subject design to establish a psychoeducational profile and evaluation of a pair of twins suspected of having hyperlexia. With consent from the subjects' parent, the author administered a word recognition assessment and used other sources of psycho-educational assessment reports to establish their profiles to provide a differential diagnosis.

Participants' Case History

Harry and Amy (not actual names), age 3 years 9 months, are the male and female twin subjects respectively in this case study. They are a set of fraternal twins conceived via In-Vitro Fertilization (IVF) and were born after a dichorionic diamniotic (DCDA) twin pregnancy, which is a type of twin pregnancy where each twin has its own chorionic and amniotic sacs. When their mother was pregnant with them, she had gestational diabetes, eclampsia, high blood pressure and weekly progesterone shots. The twins were delivered premature at 34 weeks via Cesarean section (C-section) because there was intrauterine growth restriction of the female twin.

Twin #1 - Harry

Harry was 4 lbs., 3 oz. when he was born premature through C-section. Initially, he had apnea and bradycardia and needed ventilation for it. In premature babies, apnea refers to a pause in breathing that is of a duration of more than twenty seconds. This causes bradycardia, which is a drop in the baby's blood oxygen level. He was on a Continuous Positive Airway Pressure (CPAP) machine for six days for his Initial Respiratory Disease/Hyaline Membrane Disease. He also had patent ductus arteriosus (PDA) which closed subsequently. Feeding was introduced and this progressed slowly to complete oral feeding. Harry was discharged with his twin sister after 25 days.

According to the twins' mother, Harry started to walk and spoke his first word around 15 months of age. Currently, he is not yet toilet-trained, nor yet able to feed himself with a spoon, though he could use one to feed others. Although he has not combined words into communicative phrases, he is able to make some requests with single words, sing some songs, name letters and numbers, and echo some phrases. He is also able to understand and follow some commonly given directions. Thus, his verbal functioning level (mental age) can be estimated to be at age 1.5 years. On the other hand, if his parent spells an animal name aloud (e.g. e-l-e-p-h-an-t) with or without a written model, he can say the name. From an early age, he was particularly interested in letters, numbers and math. He easily learned shapes, colors and animal names, can count to over 100, do addition problems (e.g. 10 + 90), and is able to use internet applications, such as finding videos on YouTube with a phone or tablet.

At the pre-school he attends, Harry does not favour art activities and has exhibited challenging behaviour with tantrums, screaming and a resistance to conform to group activities. He would not sit with a group for more than 15 minutes and though he had enjoyed being in a sports class, he would not participate in the structured activities. At home, he enjoys jumping on a trampoline, swimming, and music. He shows affection to his parents and enjoys bath time with his twin sister – he would “steal” her blanket to tease her as well. At times, he can be “super stubborn” but once a connection has been formed, he can be very sweet. He also has some sensory issues with sand and water, but this is fading lately.

Twin #2 - Amy

As mentioned earlier, Amy and her twin brother Harry were delivered premature via C-Section. This was because of her slow fetal growth and fetal malnutrition. She was born 3.45 lbs. with an abnormal Doppler ultrasound. Like her twin brother, she was put on a CPAP machine for 25 hours for Respiratory Distress Syndrome/Hyaline Membrane Disease. She was given total parenteral nutrition via an umbilical vein catheter at first, then via a percutaneous long line for 48 hours. When trophic feeds were introduced orally, she did not tolerate it well. NBM (nothing by mouth) feeds were kept for another

24 hours, then trophic feeds were re-introduced, and she slowly progressed to receiving full oral feeding. As mentioned, Amy was discharged from the hospital with her twin brother Harry after 25 days.

According to the twins' mother, Amy started walking earlier than her brother at 11 months, and her toilet training was also accomplished earlier than him at 40 months. Also, unlike her brother, she met all her developmental and speech/language milestones at the expected ages. On the other hand, she had pneumonia at 6 months and was hospitalized for two nights. Currently, she takes antihistamine medication to help with breathing and snoring at night.

Amy started reading at a very early age and currently, she reads spontaneously and fluently. She loves to talk and enjoys sports, art and music, other than reading. Her parents reported that she had undergone testing and had achieved high reading and language scores, though her cognitive scores are in the average range. At the preschool she is attending, she is ahead of her peers. Nevertheless, her interests in Disney princesses are typical of girls her age as she talks about her Ariel (Little Mermaid) costume. She tries to engage her minimally verbal twin brother and sometimes acts like a "mother hen" to him. However, there is a cautious side to her, as she needs explanations prior to new experiences. She also has an excessive need to know the schedule for the day. Hence, her mother feels that she is a rather shy and anxious child when anything new is presented to her.

Clinical findings

Twin #1 – Harry

According to the report from a Speech Language Centre in the USA, which provided Harry's diagnosis of ASD, no formal tests were carried out on Harry as he was minimally verbal. Hence, observations were made on him in engaging with materials and activities presented to him, as well as in solitary play, and in interactions with his mother. His age at this assessment was 3 years 9 months.

In the beginning, Harry was given some Lego blocks and plastic letters and numbers to play with. He was observed to enjoy spreading them out on the floor, but he did not spell any words with the letters nor build with the blocks. He periodically approached his mother and took her glasses off before putting them back on her once.

A pop-up book called Animal ABC was also presented to him, and he showed interest in the animals for a while and named them. When his mother spelled elephant, he said the word correctly. He also named some numbers and letters. In addition, he was verbally asked to add $10 + 90$, $10 + 30$ and $10 + 80$, to which he responded correctly each time.

Although he did not want to look at the book for a second time, he returned to it later, on his own.

Harry had also been observed to pick up a stack of post-it notes to play, and the clinician took the opportunity to engage him by writing names of animals on them. When asked, he responded by reading each of the names correctly as well. Subsequently, he placed the notes upside down along the edge of the table he was working at and correctly read the upside-down words when asked. When a word-to-picture match game was presented to him, he easily matched the words to pictures with the printed word below. He also matched words to pictures without printed word cues correctly when his father was working with him.

Later during the session, Harry was presented with some game applications on a tablet which were on math, first words and writing words. While prompts in the applications supported his responses, it was clear that he knew the spelling of many of the words. Also, after a few demonstrations, he was able to trace letters with his finger following the number prompts. He also could choose the correct answer to the math app addition and subtraction problems. However, over time, he just pressed any number without trying to solve the problems.

A word recognition assessment was administered by the author about a month later to measure Harry's literacy ability. The test was the Carver Word Recognition Test (Carver, 1970) for young children, and it is scaled for the age range of 4 years 6 months to 8 years 6 months. Although Harry's CA was below the lower end of the range, the test was used as he was reported to be able to recognize words and spell them. As an accommodation for his preferred style of communication, the multiple-choice answers of single words for each question were written with one word per post-it note for him to pick out the word spoken to him in the test administration. There was only one practice item on the test to familiarize him on the test procedure, to which he performed effortlessly and correctly – he took only a momentary look at the array of the five words given before picking out the correct one.

Harry was given ample time to complete the test and sometimes the word was repeated to ensure that he had heard it carefully. He was also given reminders to make sure he had looked at all the words in the array given before picking one out. There were limitations to the test of fifty questions - he had displayed signs of fatigue and the lack of interest as the test wore him out gradually. Periodically, after selecting an answer for a question, he would dash off from his seat and sprint around the room, but somehow, he was compelled to return to his worktable for the next question. Also, he had only a couple of very brief encounters with the author prior to this assessment, during which he was minimally verbal and did not sufficiently engage in eye-contact with her. Given his own home as test environment, he was nevertheless very comfortable. Snacks, music

videos and a sentence game on the iPad played during breaks kept him engaged to finish the test.

Table 1 – Results of Assessments for Harry

Item No.	Variable	Measure
1	Chronological Age (CA)	3y 9m
2	Mental Age (MA)	1y 6m
3	Carver Word Recognition Test Score	27/50
4	Carver Word Recognition Age (WRA)	5y 9m
5	CA - MA	2y 3m
6	WRA - MA	4y 3m
7	WRA - CA	2y 0m

Table 1 above shows the results of the assessments for Harry. His raw score on the Word Recognition Test (Carver, 1970) is 27 out of 50. This gives him a Word Recognition Age (WRA) of 5 years 9 months and a Stage 5 in the Word Recognition Ability Scales according to Carver. The scores are grouped at three-monthly intervals to avoid unreal exactness in giving the child a precise age level of reading. As indicated by this assessment, Harry's WRA is well above expectations for his CA and MA by about 2 years 0 months and 4 years 3 months respectively.

The errors Harry made are the phonetic type, with mid vowel sounds constituting the largest group of errors. There are nine of these, found in the words trap, jam, just, has, met, pen, bus, wing and kettle. The next most common is the initial letters error type, where there are four errors (inkpot, night, quiet and trap). For word endings, there are four of such errors (lick, you, wig and kettle). Next, there are two errors for each of the following errors types: combined vowels (boat, rain), r-controlled vowels (bird, part), letter reversals (saw, nod), and phoneme omission (place, post).

An assessment of Harry's language ability was also attempted by the author prior to the administration of the word recognition test. The test used was the Verbal Abstractions subtest of the Pictorial Test of Intelligence-Second Edition (PTI-2) (French, 2001), which is a revision of the Pictorial Test of Intelligence (French, 1964). PTI-2 is an objectively scored, individually administered test of general intelligence for both normal and disabled children ages 3 years 0 months through 8 years 11 months. The recommended testing time the Verbal Abstractions subtest was 15 to 30 minutes.

In the test, Harry was required to identify the correct picture to match the spoken description by circling the picture. There are two practice questions which were

administered before the start of the test, but he did not provide any responses to them. Even when the author pointed to each picture and asked him if it was the correct one, he would not respond. Eventually, the answer was given to him and the circling was done hand over hand with him. When he still did not provide any responses to the second practice question, the same correction procedure was repeated.

After the practice exercise, the actual test questions were administered. The author carried out the required questioning procedure to elicit responses from Harry, but he still did not attempt to point to or circle any answers. As per test requirements, no prompts or assistance was provided for him to point to or circle the correct picture. Without making any eye-contact or expressing any confusion about the instructions, he disengaged himself from the task and quietly dashed off. He did appear to be expecting the same practice questions support for the actual test question and felt let down when his expectations of prompts and assistance were not met. The testing was then stopped as he would not return to the task.

Other than administering the tests, the author made some observations on Harry's behaviour. He had a favourite spot under the dining table to lie down on and he was observed to bump the top of his head on the underside of the table as he rose from under it on one occasion. Though he cried out loudly and distressfully, he did not approach his mother for comfort even as she expressed very concerning and soothing words to him. His mother mentioned that the particular behaviour had occurred several times before. On another note, during one of the author's visits to his home, he was experiencing an urge for a bowel movement. He then quietly squatted down in one corner of the room to do the job in his diaper.

Repetitive behaviours noted by the author on him other than his trampolining is that he likes to recite the numbers indicated at the lift outside his front door as the lift goes up or down. Inside the apartment, he likes to recite the date and time on the clock by the front door periodically and enjoys being picked up by his mother to reach up to the height of the clock. Also, in one of the videos shared by his mother, he was shown to enjoy playing repeatedly with a set of number blocks by reciting the numbers in ascending order as he encloses one block with a larger sized number block over and again until the largest block is used, then he uncovers the blocks one by one while reciting the numbers in descending order.

Twin #2 - Amy

According to the report from a Speech Language Centre in the USA, several formal tests were carried on Amy as she was cooperative, and she easily engaged in joint attention to the test materials. Her age at this assessment was also 3 years 9 months, as it was carried out at the same time her brother Harry had his assessment.

Table 2 – Results of Assessments for Amy

Item No.	Variable	Measure
1	Chronological Age (CA)	3y 9m
2	WJ Reading Comprehension Age (RCA)	7y 2 m
3	WJ Word Recognition Age (WRA)	8y 11m
4	RCA - CA	3y 5m
5	WRA - RCA	1y 9m
6	EOWPVT-4 Expressive Language Age (ELA)	6y 4m
7	ROWPVT-4 Receptive Language Age (RLA)	5y 9m

Table 2 above shows the results of the assessments for Amy. Her literacy and reading abilities were assessed using two subtests of the Woodcock Johnson (WJ) Tests of Achievement. For the Letter-Word Identification subtest, she was required to read a list of words. Her score on this test was an age equivalent of 8 years 11 months, which is equivalent to a 3.5 grade level. This shows that Amy's reading decoding is well above expectations, with a word recognition age 5 years 2 months higher for her CA of 3 years 9 months. She had used both phonetic decoding and sight-reading strategies and correctly read words such as "knew", "library" and "brought".

For the Passage Comprehension subtest, Amy was required to fill in the appropriate word in a sentence or identify pictures. Her score on this test was an age equivalent of 7 years 2 months, which is equivalent to a 1.7 grade level. This shows that her reading comprehension is also well above expectations, with a RCA 3 years 5 months higher for her CA of 3 years 9 months. For all the test items, she was able to select a picture that matched the given phrase. She was also able to decode a "fill in the blank" sentence with and without a picture cue. Besides, she was able to read the test form questions and answers, as well as sentences in a book. Nevertheless, her WRA is still higher than her RCA by 1 year 9 months.

Amy was also administered the Expressive One-Word Picture Vocabulary Test – 4th edition (EOWPVT-4) (Martin and Brownell, 2011), where she was to identify out of four pictures one that represented the stimulus word which is verbally presented. She achieved a Standard Score of 138 (mean standard score 100, Standard Deviation – SD = 15), which is more than 2 SDs above typical children her age. The age equivalent of her score is 6 years 4 months, which puts her in the 99th percentile for single word expression.

The Receptive One-Word Picture Vocabulary Test – 4th edition (ROWPVT-4) (Martin and Brownell, 2010) was administered to Amy as well. In the test, she was to choose from an

array of four pictures, the one that represents the stimulus word that was verbally presented in each question. She achieved a Standard Score of 125 (mean standard score 100, SD = 15), which is more than 1.5 SDs above typical children her age. The age equivalent of her score is 5 years 9 months, which puts her in the 95th percentile for comprehension of single words as compared with typical children her age.

A further assessment of Amy's comprehension was carried out using a test called the WH Question Comprehension Test (Vicker, 2002). There are 10 questions in each of six question categories to be asked. Answers are considered correct as long as they corresponded to the category (e.g. who/a person; where/a place), regardless of the accuracy of the answers. Although the WH Question Test is not a norm referenced test, it is expected that a child of Amy's age would be able to respond to some of the WH Category questions. She did very well with full marks for two categories and only one or two errors in the other categories. The few errors that she made was linked to do telling what frightens people or being scared - she denied being scared of anything.

Other than examining Amy's ability to respond to WH Category questions by the quantitative data above, the test was reportedly used to assess her language in context and to note how she described and/or explained a concept. The qualitative data showed that her descriptions were well organized, and she had grammatical ability well above expectations for children her age. For instance, when asked the question "How do you make the letter A", her response was "make a slanted line and make another slanted line. Then go across". With another question "Why do firemen wear special clothes", her response was "Cause they don't want to burn themselves". Other qualitative data noted includes her social conversations with the clinician where she easily talked about princesses, and even sharing about herself that when she was a baby, she couldn't eat; so the doctor put a needle in her hand to feed her.

Observations were also made by the author on Amy during the visits at her home. Right from the start, she was chatty and bubbly with social exchanges, showing no reservations about meeting the author, though she had never met her before. At one instance, she defended her twin brother's aloofness by stating that he does speak to her and other family members. This is likely attributed to her being informed about the purpose of the author's visit. Her ability to provide empathy for her brother and understand the role the author was playing instantly impressed the author tremendously. During another visit when her brother was engaged in the testing, she was able to refrain herself from distracting him, though she kept looking on, appearing to be eager to take the word recognition test herself. While her brother preferred to graze on snacks when the testing was on, she was able to sit quietly at the dinner table to eat a proper meal with her mother. On yet another occasion, she got home from her dance class while the author was visiting and she happily shared about her dance outfit, as well as the dress her mother got for her in preparation for her upcoming birthday party.

DISCUSSION AND CONCLUSION

Based on the above historical and clinical findings on the twins, it can be concluded that both of them satisfy the criteria for the diagnosis of hyperlexia. This is as both have the unexpected precocity in word recognition with spontaneous reading ability. Each of them has a word recognition ability that is significantly advanced as compared to typically developing children of their age. Their word recognition ability is also significantly higher than their evaluated verbal functioning level or ability to comprehend the material that was read, which corresponds to the criteria of hyperlexia proposed by Silberberg and Silberberg (1967).

While Harry's level of comprehension cannot be assessed by conventional tests, his verbal functioning level can be estimated to be at age 1.5 years based on the report by his mother that he has not combined words into communicative phrases, but is able to make some requests with single words, sing some songs, name letters and numbers, and echo some phrases, as well as following some commonly given directions. His verbal functioning is thus in stark contrast with his twin sister's verbal expression level of 6 years 4 months as given by the EOWPVT-4. Hence, for Harry, his hyperlexia is marked by a deficit of 4 years 3 months between his WRA and MA (based on verbal functioning age). As for Amy, the discrepancy between her comprehension and word recognition is smaller since her RCA is lower than her WRA by 1 year 9 months.

As for the social and communication deficits found together with the stimming behaviours in hyperlexia for Harry, it can be concluded that there is a co-occurrence of ASD for him. There is no issue of ASD for Amy as she does not have such symptoms. Hence, Amy can be categorised under Treffert's (2011) neurotypical group with hyperlexia. In addition to the etiologic category of ASD in Harry's hyperlexia, he has exhibited an unexpected level of ability that is advanced for his age in not only literacy skills but in numeracy as well. Hence, his hyperlexia is considered a savant ability as his reading and word recognition talents are in significant disparity to his overall impairments. This is consistent with the mentioned case by Patti and Lupinetti (1993) on a young woman with hyperlexia and ASD who also has several other stunning abilities, including exceptional memory for dates and large numbers.

In addition, Harry's ability to read words upside down as noted in the report is suggestive of one of the skills that Kim Peek, the savant with the Mount Everest of memory (Treffert, 2010), had. Inexplicable as the abilities are, Harry's savant abilities could be attributed to genetic memory as purported by Treffert (2010). On the other hand, as there are "Matthew effects" (Stanovich, 1986) where the biblical concept of the rich get richer and the poor get poorer is applied to reading. Hence, his word bank would have been growing exponentially because of his perseverative interest in reading.

Other than using an etiologic category description, a snapshot of the twins' psycho-educational development can be seen from a descriptive-based system based on the parameters of language and literacy. Though the subjects are of the exact same age since they are twins, the assessments of their competencies on language and literacy show that they are at different levels of development. Amy is not only ahead of her typically developing peers in word recognition, but in comprehension as well. This is as her WRA is 5 years 2 months higher than her CA of 3 years 9 months; likewise, her comprehension age is higher by 3 years 5 months. This implies that she does not have a comprehension deficit based on her CA, and her hyperlexic reading is not a case of barking at print or is carried out without any understanding of what was being read. Like his sister, Harry's word decoding skills are well above expectations for his CA, but not advanced as much as hers, since his word decoding is advanced by about 2 years for his WRA of 5 years 9 months.

By evaluation, Harry's verbal functioning level is below his CA by about 2 years, while that of Amy's is conversely higher by about 2 years. This is as Amy's EOWPVT-4 shows that her verbal functioning level is more than 2 SDs above typical children her age, and she is in the 99th percentile for single word expression. In addition, her ROWPVT-4 puts her in the 95th percentile for comprehension of single words; and she performed beyond expectations, quantitatively and qualitatively, in answering "Wh" questions for her age. Therefore, there are no issues of concern for Amy's hyperlexia. However, the same cannot be said for Harry as his verbal functioning is lower than his CA, which results in a huge gap of 4 years 3 months between his WRA (5 years 9 months) and MA (1 year 6 months), so the remediation of the disparity for him is crucial.

While Harry's twin sister Amy has strengths in both phonemic and orthographic processing for reading, his hyperlexic profile is that of the orthographic subtype, i.e., his good reading can be attributed to strengths in using his right hemisphere brain processing for visual memory. This is as the errors he had made in the assessment of word recognition are the phonetic type, showing that he is limited by his weakness in using the left hemisphere for phonemic processing. Therefore, he would benefit from learning phonics to make fewer errors in word recognition. Phonics would help him decode unknown words phonologically as well, in order to overcome his limitation. Given that he has a greater propensity to pursue knowledge in the subject area of literacy besides numeracy and thrive in it, the feeling of success in these areas can boost his self-esteem and social-emotional health. This can help to compensate any feelings of inadequacy when it comes to doing things that are not in his forte.

For Harry's language comprehension and expression, teaching strategies that leverage on his propensity to read texts would help. Although he is reportedly affectionate with close family members, with the author, he has been observed to prefer to avoid eye-contact or pay attention to complex spoken language. Hence, there is a likelihood of him overlooking the social language and behaviour of others around him. The

assessments have found that he does not engage easily with unfamiliar social situations or unstructured/open-ended tasks based on spoken instructions such as artwork. Instead of avoiding activities that he does not like, it is recommended that better support be provided to make activities amenable to his learning style. For example, tasks can be broken down into smaller steps with written and pictorial cues to guide him with the verbal delivery. This would help him see the stages towards an end-product for him to be able to understand and stay engaged with verbal instructions. The predictability of an activity as prescribed would make him more amenable to participating in group activities, thus helping him assimilate socially.

As a lot of information on social behaviour exists in an unspoken format, Harry's default mode of avoiding eye-contact and possibly a consequent failure to observe people's facial expressions can lead to an increasingly widening gap between him and typically developing peers in understanding social situations. Unlike his sister who showed great empathy by defending his aloofness to the author as mentioned earlier, his difficulty in inferring from another person's viewpoint can be described as mind-blindness. According to Baron-Cohen (2011), such difficulties are linked to alexithymia – a condition where one lacks the ability to understand emotions. Therefore, explicit scaffolding on the observation and scripted role-play of social language and behaviour with positive reinforcement is recommended. With practice and application, he can improve in understanding instructions and making inferences on the appropriate things to say or do in social contexts. Also, schematic scaffolding of written texts such as the Scaffolding Interrogatives Method (Ng, 2014) for "wh" questions would help him with the decoding of syntax in written language, which can lead to an improvement in his listening comprehension as well.

In conclusion, it is hoped that the knowledge of what to expect and the strategies to help young children with hyperlexia shared here can be useful to educators, parents and caregivers – those whom the children depend on for their holistic care and development. Time is of the essence as undesirable behaviours can become hard-wired over time; therefore, early intervention is recommended as it can make the job of modifying a child's developmental trajectories easier. It would be good to bear in mind that hyperlexia is a syndrome which involves differences in reading abilities based on the orthographic, phonological and semantic processing, as well as the print exposure and short-term memory in individuals (Nation, 1999). Lastly, it would also help one to know that the neuroplasticity of the brain offers hope in bridging the learning gaps discovered in the diagnosis of the enigmatic splinter skill of hyperlexia in the savant syndrome.

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