Hyperlexia in a four-year-old boy with Autistic Spectrum Disorder

(short title) **Reading without Speech**

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Abstract

This paper presents a case study of a four-year-old boy with Autistic Spectrum Disorder and a mental age of approximately 1;5 who demonstrates precocious oral-reading behaviour in the absence of spontaneous speech. Tests of reading regular and irregular words, pseudowords, homographic heterophones, single sentences and texts were carried out. Performance on a variety of reading tasks suggests the ability to use grapheme-phoneme correspondences and whole word reading for decoding single words. In addition, successful reading of some homographic heterophones and semantic paraphrasing of texts suggests a level of lexical, syntactic, semantic and pragmatic development far beyond his mental or chronological age. The realisation of highly developed reading ability is paradoxical in the context of profound impairment in cognitive development and an absence of spoken language.

Introduction

The term *Hyperlexia* was first used by Silberberg and Silberberg (1967) to describe individuals whose ability to "recognise certain words is on a higher level than their ability to comprehend and integrate them" (p. 41). Furthermore, the authors suggested the existence of a "continuum of word recognition skills" independent of general verbal functioning, across both typical and atypical reading development. The presence of early and spontaneous (self-taught) onset word reading frequently co-occurs with an obsessive preoccupation with written stimuli, possibly overshadowing other developmentally appropriate activities (Aaron, 1989; Aram & Healy, 1988; Healy, 1982). Evidence suggests that word recognition processes used by hyperlexic readers are not exclusively based on visual memory, but also involve symbol mapping and decoding (Cobrinik, 1982; Glosser, Grugan, & Friedman, 1997; Goldberg & Rothermel, 1984; Seymour & Evans, 1992). Successful reading of pseudowords and irregular words indicates the likelihood that hyperlexic reading relies upon processes employed by typical readers involving both grapheme-phoneme correspondences and word-specific processes to successfully decode text (Aaron, 1994; Aram, Rose, & Horwitz, 1984; Ball, 1993; Ellis, 1993; Henderson, 1982; Perfetti, 1985; Wagner & Torgesen, 1987; Welsh, Pennington, & Rogers, 1987). The range of findings suggest the use of both visual and phonological processing for advanced decoding in hyperlexic readers, which nevertheless occurs with limited reading comprehension (Grigorenko, Klin, & Volkmar, 2003; Nation, 1999).

A number of studies reported relatively low levels of comprehension in hyperlexic readers across a range of standardised tests, single-word reading, and simple sentence stimuli (Huttenlocher & Huttenlocher, 1973; Kistner, Robbins, & Haskett, 1988; Richman & Kitchell, 1981). Some were able to comprehend short literal sentences, but demonstrated very poor text-level comprehension (Goldberg & Rothermel, 1984; Healy et al., 1982) or paraphrasing texts (Mehegan & Dreifuss, 1972). In other hyperlexic children, no discrepancy was found between single word reading and word comprehension (Goldberg & Rothermel, 1984; Temple & Carney, 1996). Snowling and Frith (1986) suggested that the factor which best predicted the hyperlexic child's reading comprehension was not that of mental age (MA) or reading age (RA), but the level of verbal ability.

Hyperlexic reading ability appears as a symptom in a variety of different co-morbid conditions including Pervasive Development Disorder (PDD) (e.g. Aram, Rose, & Horwitz, 1984; Welsh, Pennington, & Rogers, 1987), Turner Syndrome (Temple & Carney, 1996), non-specified mental retardation (e.g. Aaron, Frantz, & Manges, 1990; Cossu & Marshall, 1986, 1990; Healy, et al., 1982; Siegel, 1984), as well as those with typical, or above average, developmental trajectories (Pennington, Johnson, & Welsh, 1987). In these various studies, IQ measures have ranged from non-testable to above average, some showing higher Performance IQs (e.g. Cobrinik, 1974; Goldberg & Rothermel, 1984), with other studies reporting the opposite pattern (e.g., Fontanelle & Alarcon, 1982). Hyperlexia has also been reported in children with both impaired oral language (Aram, Rose, & Horwitz, 1984; Aram & Healy, 1988; Cobrinik, 1982;

Elliot & Needleman, 1976; Fontanelle & Alarcon, 1982; Goldberg & Rothermel, 1984; Goodman, 1972; Healy, et al., 1982; Mehegan & Dreifuss, 1972), and normally developing oral language (Pennington, Johnson, & Welsh, 1987; Temple & Carney, 1996). Thus, it seems that precocious reading ability with limited reading comprehension may appear in the context of a range of cognitive and linguistic developmental trajectories. The most common pattern described in published case reports is for hyperlexia to occur in individuals with Pervasive Development Disorder (PDD) (Grigorenko, Klin, & Volkmar, 2003).

Word decoding ability is associated with the development of syntactic, semantic and general cognitive systems in typical readers. The linguistic phenotype associated with the hyperlexic individual suggests the possibility of the independent formation of a functional word decoding system independent of other linguistic and cognitive capacities (Grigorenko, Klin, & Volkmar, 2003). Taken in this light hyperlexia could be interpreted as a type of savant syndrome. Heaton and Wallace (2004) suggest that, at earlier points in development, the pattern displayed in hyperlexia is consistent with that of other savant skills. The advanced word decoding in such children is exceptional relative to their own cognitive ability and to that expected by their chronological age. However, at later points in development, there is a ceiling on their word decoding ability, which may distinguish them from other types of savant syndrome individuals. Longitudinal studies have noted that the word recognition skill, central to hyperlexia, would appear to remain stable or decline over time, relative to measures of comprehension, due to the decay or lack of further progress in word decoding skills (Siegel, 1984; Sparks, 2001; Whitehouse & Harris, 1984).

Although there is ongoing debate about the relative significance of various co-occurring symptoms, the following characteristics appear to occur with higher frequency, and may be central to any definition of the hyperlexic phenotype (c.f. Aaron, 1994; Aram, 1997; Grigorenko, Klin, & Volkmar, 2003, Nation, 1999):

1. word-decoding ability that is higher than predicted by chronological age
2. early manifestation of decoding skills before five years
3. spontaneous onset of reading without specific instruction
4. a driven, compulsive, and indiscriminate reading behaviour
5. poor reading comprehension
6. co-existing developmental disorder

This paper presents the case of a four-year-old boy, Paul (not his real name), with a mental age estimated at 1;5 and behaviour typically associated with Autistic Spectrum Disorder (ASD). In the context of a virtual absence of spontaneous speech, this child paradoxically demonstrated a precocious ability to read single words, sentences and texts, suggesting the development of abilities pertaining to written language amidst profound impairment of more general linguistic and cognitive functions.

Case History

Paul had a chronological age (CA) of four years and three months (4;3) at the beginning of this study. He is the third child of a family of four. His birth was unremarkable. There was no evidence of hearing or visual impairment.

Motor development. As an infant Paul made no attempt to crawl, but began to walk at 10 months. He quickly gained an ability and preference for walking backwards. Independent toilet use was not firmly established until age four years, while hand dominance remains indeterminate.

Social and linguistic development. Paul demonstrated very little interest in social interaction with other people, or with objects such as toys. His mother reported that Paul babbled as a toddler, and produced his first word, /mɒmɒ/, at about six months. She recalled that at approximately 12 months he stopped speaking although he did hum to himself, which is typical of ASD developmental trajectories (Aram, 1997). At age 3;9, his speech was reported to be restricted to repeating set phrases out of context and echolalic behaviour.

Reading development. At age 1;11 he was first observed looking through newspapers; his mother noted that there was an intensity in his study. By 3 years, Paul was reciting the alphabet and number names, and was reading aloud printed words. His mother considered that his reading skills "just happened". Paul has grown up in a book-rich home environment. His older brother (22 years) was also reported to have been a prolific reader at an early age and showed advanced drawing abilities. The two sisters (20 and 1;11) both appear to be developing typically. Maternal history reveals good levels of literacy, whilst paternal history is unknown.

Mental development. An Educational Psychologist's assessment, given when Paul was age 3;11, determined his speech and language skills to have developed at not greater than a 17 month level, and his cognitive performance at a 16 month level, based on the *Griffiths Mental Development Scales* (1984). The significant delays in language, play, and social interaction suggested a diagnosis of ASD.

Paul attended a nursery with typically developing children where one of the authors (KA) was a teacher. At the time of testing Paul did not produce any spontaneous speech except when reading aloud or echoing nursery rhymes. Due to Paul's short attention span the number of stimuli and task presentations were very limited.

Method

A series of 12 sessions, each of 20-30 minutes duration, were recorded over a 4month period (CA 4;3 to 4;7). All sessions were held in a room familiar to Paul at the nursery school. The room had minimal distraction (blank walls; no play materials

available other than those presented for the immediate activity), the worktable faced a wall, and KA sat next to Paul. Only Paul and KA were present. Audio recordings were made for later transcription, supplemented with observational notes to aid contextualisation.

Materials

Printed stimuli. All printed word stimuli were produced using Century Gothic size 72 font. All single-word stimuli were presented on laminated 3-inch x 5-inch white paper. Sentence stimuli were produced with text of similar font (size 48) and presented on paper sizes that accommodated the full sentence. The miscue analyses were conducted using the original illustrated texts (Arial font). All single word-reading activities were presented one word at a time in isolation (unless otherwise indicated).

Auditory-verbal and visual-verbal comprehension. A variety of tasks were used to assess recognition, recall, and comprehension of oral language utilising auditory, visual, and verbal modalities:

1. Nursery rhymes: KA modelling both orally and gesturally, encouraging Paul to vocalise through anticipatory pauses (waiting for a response from Paul before continuing the rhyme).
2. Lexical labelling using objects, pictures, and environmental sound stimuli (each presented in isolation).
3. Number symbol --presented in sets of 3 numbers).
4. Acting out a known text with story props --"Little Rabbit Foo Foo" (Rosen & Robins, 1990)).
5. Utilising word-order -- 3 active sentences with corresponding real objects, each sentence/object correspondence presented in isolation) and probable-event strategies --3 sets of three words (subject, object, verb) with corresponding real objects, each word set/object correspondence presented in isolation (Tager-Flusberg, 1981).
6. Sentence-picture matching -- single sentence matching one of two pictures scanned from two texts "Not now, Bernard" (McKee, 1980) and "Knock knock, who's there?" (Grindley & Browne, 1985).
7. Cloze procedure --2 sentences with 3 word choices: semantically appropriate, grammatically appropriate, semantically and grammatically inappropriate (Snowling & Frith, 1986).
8. Photo-sentence matching -- 4 sets of 3 pictures and 3 related sentences, presented one set at a time. All photographs illustrated Paul at play in the nursery school or at home.
9. Verb-noun priming -- 2 sets of words: 5 verbs and 5 nouns, each set presented one word at a time.

Reading: Single-word. Stimuli were presented with a variety of features (regularity, irregularity, multi-syllabic, pseudoword, alternative visual presentation) in order to establish data revealing the nature of Paul's decoding abilities at a single word level:

1. Regular-irregular word pairings: Following the procedure used by Aram,

Rose, & Horwitz (1984) regular (n=18) and irregular words (n=18) were presented in pairs, e.g. tooth/blood, maker/water, etc. Only one word was presented at a time followed by its pair. Regular words were presented first except where indicated (Table 1).

2. Homophones: Stimuli were taken from Ellis (1993). Each pair (n=6) was present together, one pair at a time (Table 2).
3. Multisyllabic words: Stimuli taken from taken from Aram, Rose, & Horwitz (1984) (n=10) and Marcel (1980) (n=7), each word presented one at a time (Table 3).
4. Pseudowords: Stimuli were taken from Healy (1982) (n=8). Each word was presented individually (Table 4).
5. Irregular targeting and priming effects of pseudoword pairings: A second study of Paul's response to pseudowords was carried out to probe whether he could learn a novel irregular pronunciation for a nonce word. Pseudowords (n=8) were presented one at a time. The words were presented a second time and each was given an irregular reading by KA followed in-turn by a response from Paul. The words were then re-presented a third time for Paul to read. One week later the same 8 pseudowords were presented again in pairs with a novel pseudoword having a different initial onset but the same coda, e.g. grood/jood, binth/pinth, etc. This was carried out in order to determine whether Paul could generate irregular pronunciations or apply regularised pronunciation to novel nonce words. Each of the previously presented pseudowords was presented individually followed directly by the novel paired pseudoword and acted as prime for the novel set (Table 5).
6. Visually deviant presentation of words: The logographs '&, £ and $', novel graphs in the form of Greek letters and eight visually deviant words taken from Goldberg & Rothermel (1984) were presented to Paul (Tables 6 and 7).

Reading: Sentence-level. Paul was given a series of simple sentences to read within some of the activities designed to ascertain visual-verbal comprehension:

1. The stimuli involved word order strategies (Tager-Flusberg, 1981).
2. Sentence-picture matching.
3. Photo-sentence matching.

Reading: Text-level. Two types of task were administered at a text-level:

1. Homographic heterophones: 4 short texts taken from Ellis (1993) were presented for reading (Table 8).
2. Miscue analysis: 2 storybooks were used: *Not now Bernard*. (McKee, 1980) (Session 1 and 2) and *Little Rabbit Foo Foo.* (Rosen & Robins, 1990) (Session 8 and 9) (Tables 9 and 10).

Data analysis

All activities were transcribed lexically, supplemented with contextual details relating to the response of Paul to the stimuli. Specific phonetic transcriptions were used for all non-target productions by KA who is trained in phonetics and the use of the

International Phonetic Alphabet (IPA). Single word reading analyses focused primarily upon grapheme-phoneme correspondences and word-specific print-to-sound associations. The sentence level and text level miscue analyses focused on reading accuracy and were transcribed lexically, with phonetic transcriptions at points of non-target productions.

Results

In order to place Paul's reading ability within context, it is necessary to consider his broader linguistic and cognitive abilities. Hence, initially, consideration will be given to the auditory-verbal and visual-verbal comprehension tasks. Detailed analysis of the reading performance will then be considered.

Auditory-verbal, visual and written comprehension

There was no clear evidence of comprehension demonstrated on any of the tasks presented. Only 3 out of 17 objects, pictures, or environmental sounds provoked any form of response. In his response to nursery rhyme activities, Paul was able to echo and produce some instances of non-verbatim echoing. The presentation of 4 series of numerals resulted in a string of out-of-immediate-context utterances, for example: when looking at the set of numbers '1', '6', and '16', Paul's response was "One [pause] million pounds… One cent. Six p a pound. Six a cent. Six sixteen p a pound. Sixteen cent… One p a pound. One cent" ('p' is the abbreviated lexical label for 'pence'). Such responses suggested that, in addition to acknowledging the number symbol, Paul appeared to associate the printed stimuli to a local street market context (where traders shout repetitive phrases such as "16 p. a pound") with which he was very familiar.

In written word matching to object stimuli, Paul did little beyond text decoding, while ignoring all of the objects. In none of the sentence-picture matching, cloze procedure, photo-sentence matching, and verb-noun priming activities did Paul demonstrate any response to the specific tasks. In summary, we were unable to demonstrate any auditory-verbal or written comprehension due to an absence of spontaneous speech, pointing, or pretend play responses to materials.

Single-word reading

Consideration of non-target pronunciations. In all of the analyses presented below, it is notable that a proportion of Paul's responses contain phonetic approximations (a larger proportion occurring on 2- and 3-syllable words), which do not correspond to any grapheme-phoneme patterns in English. As Paul does not produce any spontaneous speech it was difficult to determine his level of oral-motor control.

Inspection of these “deviant” pronunciations suggests that these forms might be a reflection of poor articulatory coordination rather than inaccuracies in reading per se, e.g., /ˈbɔtə/ for water; /fwʊd/ for flood; /wɒnθ/ for once; and /ˈkæŋəraʊ/ for kangaroo. In addition, Paul’s oral behaviour during reading tasks displayed instances of pallilalia (characterised as an increasing build-up of speech accompanied by a progressive decrease in volume, resulting in a meaningless jumble), which has been documented in other cases of hyperlexia (Cobrinik, 1982; Healy, et al.; 1982; Goldberg & Rothermel; 1984; Mehegan & Dreifuss, 1972). Mehegan and Dreifuss (1972) have suggested that such abnormal prosodic characteristics are evidence of a motor-speech disorder, whereas others (Aram, Rose, & Horwitz, 1984) have suggested that such characteristics reflect a failure to comprehend and use syntactic and semantic features appropriately.

Regular and Irregular words (Table 1). Paul demonstrated an awareness of both regular grapheme-phoneme correspondence rules and word-specific print-to-sound-associations. He correctly read-aloud 12/18 regular words, and 10/18 irregular words. In correctly reading aloud 7/18 regular-irregular word pairs, Paul demonstrated an awareness of word-specific print-to-sound-associations despite the priming effect of regular grapheme-phoneme correspondences. In a small number of instances, Paul regularized irregular words 3/18, and produced irregular pronunciations for regular words 3/18 (where the irregular correspondence exists within the English orthographic lexicon) (Table 1).

Table 1: Regular & Irregular Single-word Reading

Regular-irregular word pairings: taken from Aram, Rose, & Horwitz (1984)					
regular			**irregular**		
tooth	/tuθ/	✓R	blood	/blʊd/	✓I
maker	/'meɪkə/	✓R	water	/æ/ /'bɔtə/	× N
soft	/sa/ /sɒft/	✓R	both	/buθ/ /boʊθ/	✓I
whip	/wɪp/	✓R	whom	/wɒm/	×R
goes	/goʊʒ/	✓R	does	/doʊʒ/ /dʌʒ/	✓I
liquid (2nd)	/liəkwɪd/ /likwɪd/	✓R	liquor (1st)	/ɪʒə'koʊə/	× N
open	/'ɒpən/	×I	once	/wɒnθ/	× N
motor	/'moʊvə/	×N	woman	/wɪ'mɛn/ /wə'mæn/	✓I
divine	/'divin/	×I	marine	/'mæraɪn/	×R
summit (2nd)	/sʌ'mɪt/	✓R	sugar (1st)	/ʃə'ga/	✓I
couch	/kʌtʃ/ / kɒtʃ/	×I	touch	/tʌtʃ/	✓I
wheel	/wil/	✓R	whole	/waʊl/ /waʊwaʊ/	× N
boost	/bust/	✓R	flood	/fwʊd/	× N
hose	/haʊs/	×N	lose	/loʊs/	×R
suck	/sʌk/	✓R	sure	/ʃɔ/	✓I
tone	/toʊn/	✓R	gone	/gɒn/	✓I
honey	/hɒnɪ/	✓R	hour	/haʊs/ /aʊə/	✓I
advice	/ɪd'vaɪs/	× N	police	/pə'lis/	✓I

Key: ✓R correct pronunciation of regular word

✓I	correct pronunciation of irregular word
×R	regularised pronunciation of an irregular word
×I	irregularised pronunciation of a regular word (where correspondence exists within the English language lexicon of irregular words)
×N	non-target pronunciation

Homophonic word reading (Table 2). Of the 12 words presented in total, 6 were read correctly however, as pairs only 2 were both correct, and 1 pair ("which"/"witch") was consistently mispronounced (Table 2).

Table 2: Homophone Single-word Reading

Homophones						
	Stimuli	**Response**		**Stimuli**	**Response**	
	you	/juː/	✓	yew	/ju/	✓
	pear	/pɛəu/	×	pair	/pɛə/	✓
	which	/wɛtʃ/	×	witch	/wɛtʃ/	×
	too	/tu/	✓	two	/tu/	✓
	threw	/θru/	✓	through	/θrɔ/	×
	kernel	/'kɛəgəl/	×	colonel	/'kwɜrnəl/	×

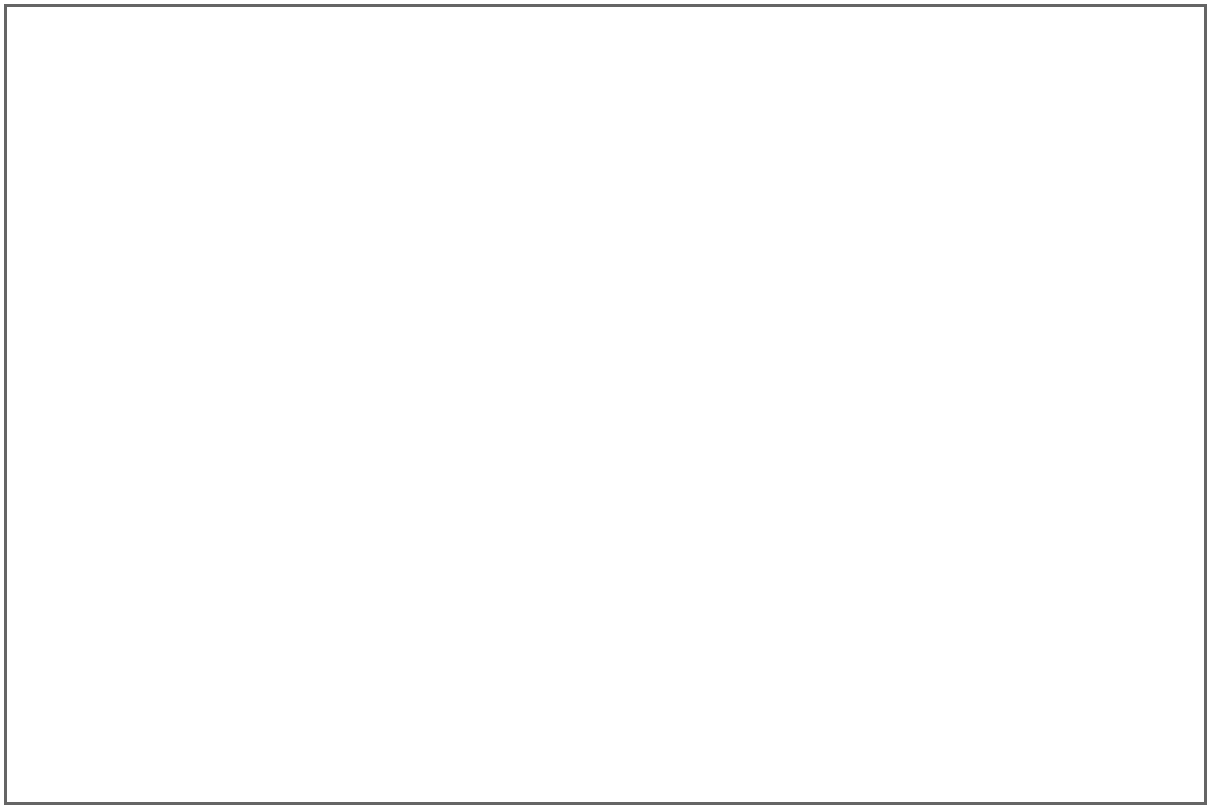
Key: ✓ correct pronunciation

× non-target pronunciation

Multisyllabic word reading (Table 3). This task was more difficult for Paul. He only read 6/17 completely correctly ('present' 'compact', 'contrast', 'desert', 'collate' and 'collative'). However, his performance suggests some ability to correctly assign prosodic stress to multi-syllabic words, which is variable in English. One word ("confining" pronounced /'kɒnfaɪn/) was read with the final syllable absent which may be attributed either reading inaccuracy or a lack of morphological awareness. (Results of the miscue analyses (below) suggest the increased likelihood of reading inaccuracy. However, a lack of morphological awareness cannot be completely dismissed as the virtual absence of spontaneous speech meant that syntactic knowledge could not be assessed.) Non-target pronunciations involving only a single phoneme (e.g. /i/ rather than /ɪ/, /ɪ/ rather than /ɛ/) occurred in reading three of the stimuli.

Table 3: Multisyllabic Single Word Reading

Multisyllabic Words		
Stimuli	**Response**	
taken from Aram, Rose, & Horwitz (1984):		
kangaroo	/ˈkæŋəraʊ/	× - final vowel
stadium	/stəˈdɪˌɛm/	× - 1st & 3rd vowel
confining	/ˈkɒnfaɪn/	× - omission of final syllable
amphibian	/ˈkɒpɪənˌpɒpɪən/ /ˌɒˈpɪən/	×
present	/ˈprɛəˌʒənt/	✓
rebel	/ˈriˌbəl/	× - 1st & 2nd vowel
compact	/kɒmˈpækt/	✓
contrast	/kɒnˈtræst/	✓
desert	/ˈdɛʒɜrt/	✓
project	/ˈkɒdʒɛkt/	× - initial consonant
taken from Marcel (1980):		
telegraph	/ˈtɛlə/ /ˈtɛləˌgrɒg/	× - final consonant
telegraphic	/tɛˈlɪˌgrɒfɒfɪk/	× - repeated consonant
telegraphy	/tɛlɪgrɒfɪ/	× - 2nd vowel
relate	/ˈiweɪt/	× - 1st & 2nd consonant
relative	/ˌiˈreɪtɪv/	× - 1st & 2nd consonant
collate	/kəˈleɪt/	✓
collative	/kəˈleɪtˌɪv/	✓



Pseudowords (Tables 4 and 5). Table 4 illustrates the response of Paul to the presentation of single pseudowords (Healy, 1982). Of these pseudowords, 3 were pronounced correctly while the other 5 were close approximations.

Table 4: Pseudoword Reading

Pseudowords					
Stimuli	**Response**		**Stimuli**	**Response**	
pnir	/pə'wi/	×	wip's	/wɪps/	✓R
ap	/æp/	✓R	bim	/blɪm/	×
dee	/di/	✓R	gnouthe	/goʊwɒwaθ/	×
jvence	/dʒus/ /dʒu/	×	wubfambit	/wʊf/ /fæm'bɪt/	×
Key: ✓R	regularised pronunciation				
✓I	irregularised pronunciation				
×	non-target pronunciation				

The second pseudoword study was carried out to probe whether Paul could learn a novel irregular pronunciation for a nonce word. On first presentation, Paul spontaneously gave "regular" pronunciations for 3, while 4 others were given "irregular" pronunciations on his first reading (Table 5). The words were presented a second time, and each was given an irregular reading by KA, which Paul accurately repeated. On the third presentation, only 1 pseudoword for which Paul had spontaneously given a regular reading was now decoded with the irregularised pronunciation.

One word (datch), initially regularised, was irregularised on the third reading, reflecting adult modelling, whilst 1 word (koader), initially irregularised, was regularised on the third reading despite adult modelling. On the third reading of 1 word (grood), Paul reiterated his first regularised reading, whilst on the third reading of another word (wusy), Paul more closely targeted his first reading of the regularised vowel sound rather than the modelled irregularised vowel.

Table 5: Modelling of "Irregular" Pseudoword Reading

Irregular pseudowords

1st session

Stimuli	Paul's spontaneous reading	Modelling by KA	Immediate repetition	2nd reading (order of presentation)	
grood	/grud/ ✓R	/grʊd/	/grʊd/ ✓	/grud/ (6)	✓R
binth	/bɪ'diθ/ ×	/baɪnθ/	/baɪnθ/ ✓	/boʊi/ (7)	×
datch	/dætʃ/ ✓R	/dɒtʃ/	/dɒtʃ/ ✓	/dɒtʃ/ (8)	✓I
fose	/fuʒ/ ✓I	/fuʒ/	/fuʒ/ ✓	/fuʒ/ (3)	✓I
wouzle	/wʌʒəl/ ✓I	/wʌʒəl/	/wʌʒəl/ ✓	/wʌʒəl/ (1)	✓I
koader	/kɔdə/ ✓I	/kɔdə/	/kɔdə/ ✓	/koʊdə/ (2)	✓R
gdour	/goʊdaʊə/ ✓I	/gədaʊə/	/gədaʊə/ ✓	/gədaʊə/ (4)	✓I
wusy	/wʊʒɪ/ ✓R	/wɪʒɪ/	/wɪʒɪ/ ✓	/wuʒɪ/ (5)	✓R

2nd session (one week after 1st session)

Stimuli	Response	Stimuli	Response
grood	/grʊd/ ✓I	jood	/jʊd/ ✓I
binth	/baɪnθ/ ✓I	pinth	/paɪnθ/ ✓I
datch	/dɒtʃ/ ✓I	batcher	/bɒtʃə/ ✓I
fose	/faʊʒ/ ×	tosing	/tɔʒɪŋ/ ×
wouzle	/wʌʒəl/ ✓I	gouz	/gʌʒ/ ✓I
koader	/kɔdə/ ✓I	floader	/flɔdʊə/ ✓I
gdour	/gɔdaʊ/ ✓I	fbour	/fəbaʊə/ ✓I

wusy	/wʊʒɪ/ ✓R	kusy	/kɪʒɪ/	✓I

✓R – correct regularized reading

✓I – correct irregularized reading

× - non-target pronunciation

Of the 14 pseudowords read correctly in the second session, all but 1 was given an irregularized reading on this task. In reading the final pair (wusy and kusy), Paul regularised the prime (/wʊʒɪ/) as he had done the week before, but produced an irregularised reading for the paired pseudoword (/kɪʒɪ/).

Visual word analysis. While '&' was read as "and"; '£' and '$' were both read as "million dollars". The response would appear to reflect the real world context in which Paul has previously encountered such orthographies. However, the same lexical reference was drawn for both the '£' and the '$' logograph.

Table 6: Presentation of Novel Greek Letters

Greek letters

Stimuli	Response
α	/sɪks/ “six”
β	/pi/ “p”
γ	/waɪ/ “y”
δ	/sɪks/ “six”
ε	/i/ “e”
π	/titi/ “T T”
σ	/oʊ/ “o”
θ	/eɪt/ “eight”

Table 7: Visually Deviant Word Reading

Visually deviant words	
Printed Form	**Response**
HOme	/hoʊm/ ✓
c	
r	/kraɪ/ ✓
y	
n	
lo	/ælɒlɪdʒ/ /eɪ/ /lɒŋɪ/
g	

⅂ᗡᑐ	/kæ/ /ka/ ✓
kit t en	/kɪtɛn/ ✓
b u S	/bʌs/ ✓
g+o+o+d	/gɔd/
biRD	/bɜd/ ✓

Table 6 illustrates the response of Paul to the presentation of individual Greek letters. In all cases, Paul responded with known English grapheme-phoneme or grapheme-number correspondence that most closely resembled the presented orthographic representations.

In presenting Paul with a series of visually deviant words, he seemed to have little difficulty reading these distorted visual word forms with 6/8 completely correct and 2 approximations (Table 7).

Sentence-level reading.

Paul's responses to the sentence stimuli demonstrated a great deal of variability. It was not clear that he understood what was expected. In some instances, Paul only read aloud some lexical items, e.g., "dog [pause] hat" for the sentence 'The dog wears the hat'. Word order was not always maintained, e.g., "car truck [pause] hits car truck" in response to the written sentence 'The car hits the truck'. Prior to reading the two sentences "I'm a great big gorilla." and "The monster bit Bernard's father." Paul gave a spelling response naming each letter in sequence. However, sentences such as "I am on the slide" and "[Paul] is playing with the clay" were read completely correctly.

Text-level reading.

Homographic heterophones in context (Table 8). In the first text, the target word "tear" was pronounced semantically and grammatically correctly for both instances i.e., /tɛə/ and /tiə/. In the second, the target word "sow" was pronounced incorrectly but differently in the 2 instances. Whereas, in the last 2 texts 1 of the pair was produced correctly for the grammatical and semantic context, while the second was not. As discussed above, there is no independent way of ascertaining whether words such as "sow" are in Paul's lexicon for either meaning. He is a 4-year-old child with very limited life experience and it is likely that these were nonce words for him.

Table 8: Homographic Heterophones

Homographic heterophones	
Stimuli	**Response**
1. She was deeply unhappy. The material	she was deeply /ʌglɪ/ the material
of her dress had a large tear in it	of her dress had a large /tɛə/✓ in it
and in the corner of her eye	and in the corner of /joʊʒə/ /i/
a tear was forming.	/waɪ/ a /tiə/✓ was forming
2. At the farm the piglets slept next to the	at the farm the piglets to the
sow, while in the garden the farmer	/snə/ while in the garden the /əf/
began to sow the lettuce seeds.	began to /sdʌ/ the lettuce seeds
3. A musician played the big bass	a musician /pleɪəd/ the big /bas/
drum outside the fish restaurant	drum inside the fish restaurant
where the best fish to eat was the bass.	where the best fish to eat was the /bæs/✓

4. It took one minute for the minute ant to climb up the table.	it took one /mɪnɪt/✓ for the /mɪnɪt/ ant to climb up the table

Reading story books. The first miscue analysis, conducted in Session 1, included a high degree of distractible behaviour, however, 40/56 words in the text that was read aloud were read correctly. On the second reading a week later, Paul read aloud a larger portion of text with 105/122 read accurately with only 5 non-target pronunciations. In sessions 8 and 9, the second story was presented for miscue analysis, during which he read a significantly larger number of words.

Table 9: Results of the Miscue Analyses

Error Type	"Not now, Bernard" 1st reading		"Not now, Bernard" 2nd reading		"Little Rabbit Foo Foo" 1st reading		"Little Rabbit Foo Foo" 2nd reading	
	n=56	%	n=122	%	n=196	%	n=207	%
Words correct	40	71	105	86	142	72	178	86
regularisation	0	0	0	0	1	0.5	0	0
non-target	14	25	5	4	25	13	10	5
paraphrasing	1	2	2	2	7	3.5	9	4
repetition	1	2	5	4	0	0	2	1
omission	0	0	4	3	17	9	9	4

self-correction	0	0	1	1	4	2	0	0
% of full text read aloud	36		79		84		89	

Table 10: Paraphrase Examples and Self-corrections from Miscue Analyses

	Text	Oral Reading
Paraphrasing	upstairs	up the up the stairs
	The monster ate the dinner	the monster ate all dinner
	Then it watched the television	then it watched all the television
	I'm going	I'm am going
	chances to change, and if you don't I'm going riding through the forest	chance so I'm going riding through a forest (3 occasions)
	I'm going to give you two chances	I want two chances
	the tigers	a tiger
	I'm going to turn you	I turn you
	Down came the Good Fairy	down came a good fairy (2 occasions)
	I'm going to give you three chances to change	I'm going a three chance a change
	I'm going to give you two chances to change	

	You've got one chance to change	and you two chances to change
	bopping	
	You've got no chances left	you've got one chance a change
	so I'm going	bop bop bop bop
		you got no chance left
	mother	so I am going
	and said	
self-correction	riding	/ma/ mother
		/eɪ/ say and said
		/raɪ/ riding

Of particular interest, are the occurrences of paraphrasing, which at a sentence level were semantically coherent (Table 10).

Discussion

Paul shows a precocious reading ability for his chronological age (CA) of 4 years, but this is even more paradoxical given his mental age (MA) estimated at 1;5, and a virtual absence of spontaneous speech. His early history includes the expected early and spontaneous manifestation of reading behaviour, far in advance of his chronological age, alongside poor comprehension.

Paul demonstrated an unexpected precocious ability to read along with an inability to generate meaningful linguistic, communicative, symbolic, and imaginative play; behaviours that would otherwise be associated with a typically developing 4 year-old child. There is no evidence that Paul can manipulate linguistic units in any productive or communicative sense. Oral language behaviour was only produced in response to printed text apart from some echolalia and repetitive fixed phrases. However, some higher level of lexical, syntactic, and semantic development may be inferred from his reading behaviour in the miscue analysis and homographic heterophone texts.

The majority of the single-word stimuli employed in this investigation were drawn

from studies developed for subjects who were both older by CA, and cognitively and linguistically less severely impaired than Paul. The majority of these studies have been conducted with individuals whose IQ measures would suggest the ability to comprehend, at some level, both the task and stimuli presentation (e.g. Aram, Rose, & Horwitz, 1984; Goldberg & Rothermel, 1984; Healy, 1982; Healy, et al., 1982). There was little evidence of any development of linguistic and cognitive abilities in Paul which could be elicited, although numerous and various stimuli and tasks were employed. His very limited cognitive development and limited life experiences strongly suggested that both his passive lexical knowledge and world knowledge were also likely to be very limited. However, the fact that there is a virtual absence of spontaneous speech means that any measure of mental age can only be estimated. It is possible that Paul's mental age is in fact closer to his chronological age than would be suggested by his performance on the *Griffiths Mental Development Scales* (1984).

This study presents a snapshot of hyperlexic reading at 4 years. Little information is available with regard to this child's pattern of reading and language at the onset of literacy aged 3, nor can we predict what trajectory his speech and literacy development may take. In studies that have followed hyperlexics over time, word recognition skills have appeared to plateau (Siegel, 1984; Sparks, 2001; Whitehouse & Harris, 1984). Paul's ability to learn "irregular" pronunciations to pseudowords demonstrates that he had extremely advanced decoding skills and that active reading acquisition is ongoing. When Paul was presented with novel Greek letters, his response was to decode them as English letters and numerals. This behaviour is possibly indicative of the type of driven, compulsive, and indiscriminate reading behaviour associated with hyperlexia.

Although there is no direct measure of Paul's reading age, an attempt was made to gauge the level of reading vocabulary that Paul appears to have mastered. All the words Paul successfully read were submitted to the *Children's Printed Word Database* (Masterson, et al., 2003) to gain an estimate of his reading level. This is a database of words contained in books read by children aged 5-9 years of age. Inspecting the frequencies (per million words in texts) suggests that Paul was able to read many words that appear rarely or never in texts for children up to age 9 years.

Both Pennington, Johnson, and Welsh (1987) and Snowling and Frith (1986) have argued that the level of verbal ability was the factor which best predicted the level of reading comprehension in hyperlexia. The implicit reading comprehension inferred from Paul's performance would not be predicted give the absence of verbal production, while his mental age would predict only the most rudimentary understanding of single words.

The level of comprehension at a single word level could not be determined due to

Paul's lack of spontaneous speech or response to objects and pictures generally. In consideration of his CA and MA, there is the possibility that many real words that were used as stimuli in this study may have the status of nonce words for Paul (e.g., the homophones "kernel" and "colonel"). In reading isolated sentences, Paul appeared to treat them as strings of individual words rather than propositions. He never responded to any written direction (e.g. "Put on your hat") with an action. Rather, it would appear that simple decoding was the pre-eminent, and possibly only, linguistic process that was being carried out.

At the same time, his successful reading of irregular words and some heterographic homophones in context suggests the presence of a larger semantic lexicon than would be expected from his CA or MA. Examples of paraphrase readings of texts such as "a tiger" for 'the tigers'; "chance so I'm going" for the text 'chances to change, and if you don't I'm going'; and "I want two chances" for the text 'I'm going to give you two chances' imply the ability to use syntactic and pragmatic knowledge in the interpretation of written language. Such behaviour could be taken as an unexpected but implicit indication of comprehension at the sentence level. This also suggests that Paul is not simply mechanically decoding print, but carrying out some level of linguistic processing of text. Paul also made immediate self-corrections of his errors without prompting, suggesting that he may have been monitoring his oral reading. These productions are unexpected in a child who does not demonstrate any other evidence of linguistic development, produces no spontaneous speech, nor any other non-verbal communicative behaviour. However, the number of observations is low, and the possibility of chance affecting the data cannot be dismissed. The possibility must be acknowledged that in the miscue analyses, the occurrence of semantic paraphrasing may be the result of simple random errors giving the appearance of semantic coherence.

Conclusion

This study presents a case of precocious oral reading behaviour, co-occurring with severe Autistic Spectrum Disorder in a 4 year-old boy. Oral language was only produced in response to written stimuli, although no ability to respond to written text in a meaningful way could be elicited. However, Paul's production of correct heterographic homophones in context and his production of semantic paraphrases which maintained syntactic consistency across words implies a level of linguistic development far beyond that which would be predicted by his MA of 1;5. Such findings suggest the possibility of an atypical route to language acquisition. Existing cognitive accounts are inadequate to account for the development of literacy in this child.

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