

Annotation: Hyperlexia: disability or superability?

Elena L. Grigorenko,^{1,2,3} Ami Klin,¹ and Fred Volkmar^{1,2}

¹Child Study Center, Yale University, USA; ²Department of Psychology, Yale University, USA; ³Department of Psychology, Moscow State University, Russia

Background: Hyperlexia is the phenomenon of spontaneous and precocious mastery of single-word reading that has been of interest to clinicians and researchers since the beginning of the last century. **Methods:** An extensive search of publications on the subject of hyperlexia was undertaken and all available publications were reviewed. **Results:** The literature can be subdivided into discussions of the following issues: (1) whether hyperlexia is a phenomenon that is characteristic only of specific clinical populations (e.g., children with developmental delays) or whether it can also be observed in the general population; (2) whether hyperlexia is a distinct syndrome comorbid with a number of different disorders or whether it is a part of the spectrum of some other clinical condition(s); (3) whether hyperlexia should be defined through single-word reading superiority with regard to reading comprehension, vocabulary, general intelligence, any combination of the three, or all three characteristics; (4) whether there is a specific neuropsychological profile associated with hyperlexia; (5) whether hyperlexia is characterized by a particular developmental profile; and (6) whether hyperlexia should be viewed as a disability (deficit) or superability (talent). **Conclusions:** We interpret the literature as supporting the view that hyperlexia is a superability demonstrated by a very specific group of individuals with developmental disorders (defined through unexpected single-word reading in the context of otherwise suppressed intellectual functioning) rather than as a disability exhibited by a portion of the general population (defined through a discrepancy between levels of single-word reading and comprehension). We simultaneously argue, however, that multifaceted and multi-methodological approaches to studying the phenomenon of hyperlexia, defined within the research framework of understanding single-word reading, are warranted and encouraged. **Keywords:** Autistic disorder, comprehension, dyslexia, pervasive developmental disorder, reading, specific language impairment.

Although references to the phenomenon of spontaneous and precocious mastering of single-word reading¹ have been presented in the literature on children with impaired intellectual abilities since the beginning of the last century (e.g., Bender, 1955; Bergman & Escalona, 1948; Eisenberg & Kanner, 1956; Kanner, 1943; Mahler & Elkisch, 1953; Manner, 1943; Parker, 1919; Phillips, 1930), the term 'hyperlexia' – now used to describe these unusual abilities with printed words – was introduced only in the late 1960s (Silberberg & Silberberg, 1967, 1971). However, soon after the introduction of this term to the literature (for early reviews, see Cain, 1969), a similar phenomenon, capturing the discrepancy between the levels of decoding and comprehending printed words (i.e., precocity of single-word reading emerging ahead of the development of comprehension), was observed both in children with typical (Niensted, 1968) and superior IQ (Jackson & Bie-miller, 1985; Pennington, Johnson, & Welsh, 1987). This 'extension' of the phenomenon from atypical to typical development assumed 'a continuum of word

recognition skills which may exist separate and apart from general verbal functioning' (Silberberg & Silberberg, 1967, p. 41). It is precisely these two assumptions about hyperlexia (i.e., the assumption that single-word identification skills are distributed continuously and the assumption that this distribution, at least in its extremes, is independent of the distribution of general verbal functioning) along with the observation that hyperlexia was initially 'registered' among children with developmental disabilities that constitute the basis for the discussion in this annotation.

Specifically, with regard to the first assumption, if word recognition skills are distributed continuously, then those who are below a certain threshold can be viewed as individuals whose word identification is impaired (i.e., those possessing a disability) and those who are above a certain threshold can be viewed as individuals whose identification is advanced (i.e., those possessing a superability). Thus, if hyperlexia is defined as advanced word recognition, then it can be viewed as a superability. This assertion is certainly plausible, given that the second assumption is correct (i.e., superability in word recognition can manifest itself independently of the general level of verbal ability). Yet, the phenomenon of hyperlexia was registered for the first time in a profoundly disabled population and even referred to as 'pseudo-talent' (Parker, 1919). This continuing confusion regarding the meaning of the term

¹ For the purpose of this annotation, we are using the terms *word decoding*, *word recognition*, *word calling*, and *word identification* synonymously. When the term *decoding* is used to signify decoding of nonwords (i.e., the connotation of the term primarily employed in the field of developmental dyslexia), we indicate that by using the term *nonword* (*pseudoword*) *decoding*.

'hyperlexia' is what motivated us to write this annotation.

Definition of hyperlexia: resolved and unresolved issues

The general contemporary definition of *hyperlexia*, accepted both in the clinical and research fields, characterizes this phenomenon as a level of word recognition (word identification) skills far above those of reading comprehension (both at the level of single words and connected text) and of general cognitive functioning of an individual (e.g., Nation, 1999; Pennington et al., 1987; Snowling & Frith, 1986). Of note is a consensual agreement that the phenomenon refers to an excess of ability to deal with the 'mechanical' (i.e., stripped of grammar, syntax, and meaning) aspects of words. There are, however, some aspects of the definition of hyperlexia on which there is little or no consensus. First, is *hyperlexia* a phenomenon that is characteristic only of specific clinical populations (e.g., children with developmental delays), or can it also be observed in the general population? Is hyperlexia a distinct syndrome comorbid with a number of different disorders or is it a part of the spectrum of some other clinical condition(s)? Second, with regard to what should this word identification superiority be defined (comprehension, vocabulary, general intelligence, any combination of the three, or all three)? Third, is there a specific neuropsychological profile associated with hyperlexia? Fourth, is hyperlexia characterized by a particular developmental profile? Fifth, is there a particular 'biological signature' of hyperlexia? Sixth, what psychological processes form the foundation for reading without meaning that constitutes the essence of hyperlexia? Finally, should hyperlexia be viewed as a disability (deficit) or a superability (talent)? In this annotation, we briefly summarize the current views with respect to these seven issues, raise several matters relative to the phenomenon of hyperlexia, and present our answer to the *disability-superability* question.

Hyperlexia: a symptom, a syndrome, or a normal variant?

The core disagreement in the field concerns the issue of whether hyperlexia is a normal developmental variant or a symptom of developmental difficulties (and, if so, what difficulties). Silberberg and Silberberg (1967) initially stressed that the phenomenon of hyperlexia was observed primarily in children with various forms of 'cerebral dysfunction' (p. 41); however, later the same authors extended the hyperlexia spectrum to the normal population, bridging normal and abnormal by talking about the continuum of word recognition skills (Silberberg & Silberberg, 1971). Both positions are still very much present in

today's literature: Some researchers are adamant about hyperlexia being a clinical phenomenon whereas others readily assign the label of hyperlexia to children with word recognition-comprehension discrepancies irrespective of any clinical diagnosis.

Hyperlexia as a variant of typical development

The term has been used to describe a normal variant of development. For example, Niensted (1968) referred to the discrepancy between word recognition and comprehension in normal readers. Similarly, Richman and Kitchell (1981) defined hyperlexia as a word recognition ability far above expected levels without making a reference to developmental delay. More recently the term *hyperlexia* was used in an investigation of the skills of a gifted boy (Pennington et al., 1987). Thus, there is a distinct line of literature in which the phenomenon of hyperlexia is defined generically, without reference to a clinical population of individuals with developmental delays.

A 'variation on the theme' of superior word recognition skills in the general population is present in the literature on precocious readers (e.g., Jackson, 1992; Jackson, Donaldson, & Cleland, 1988; Pennington et al., 1987). In this literature (e.g., Pennington et al., 1987), hyperlexia is viewed as a type of precocious reading, so that precocious reading refers to precocious reading without (i.e., hyperlexic) and with comprehension (i.e., non-hyperlexic). Of interest is that such 'hyperlexic' reading can be observed even in a high-IQ population; the basis for that might be in the observation that even among children with high general ability the decoding ability factor might be statistically independent of general ability, reading comprehension, and verbal ability (Jackson et al., 1988). Similarly, it appears that verbal precocity does not result in precocious reading (Crain-Thoreson & Dale, 1992), once again suggesting that although correlated in the general population, at the extremes, general, verbal, and reading skills can be independent.

In sum, there is evidence to believe that precocious reading of single words without comprehension can be observed in children with average and above-average general and/or verbal abilities.

Hyperlexia as a variant of atypical development

Although eventually abandoned by Silberberg and Silberberg, the notion that hyperlexia is observed only in the context of some developmental problems has persisted and been adopted by a number of other authors (e.g., Healy, 1982). In some cases, it has been stated that hyperlexia might be a precursor and/or early indicator of a developmental disability (Kupperman, 1997). In this line of literature, hyperlexia has been referred to as a subtype of developmental dyslexia (DD), specific language impairment (SLI), reading comprehension disorder, and

pervasive developmental disorders (PDD). This 'hyperlexia as a subtype' approach was initially introduced by the Child Neurology Society Task Force on the Nosology of Disorders of Higher Cerebral Functions in Children (1981). The characteristic part of this approach is in distinguishing the essential (fluent oral reading, impaired reading comprehension, superior verbal memory, and adequate to superior visual perceptual skills) and variable (suppressed verbal IQ, echolalia, autistic behavior, and preoccupation with numbers) features of hyperlexia (Cohen, Campbell, & Gelardo, 1987).

Hyperlexia as a subtype of dyslexia

Whereas hyperlexia refers to a phenomenon of single-word reading being at a level higher than expected based on general cognitive skills, developmental dyslexia refers to single-word reading being at a level lower than expected based on general cognitive skills. In other words, when anchored on general ability, both conditions might involve the same processes, but capture different extremes. Based on this reasoning, as well as some evidence of high frequency of learning disorders, especially dyslexia, in families of individuals with hyperlexia (Healy & Aram, 1986), hyperlexia was classified as a subtype of developmental dyslexia (Benton, 1978; Cohen et al., 1987; DeHirsch, 1971; Healy, Aram, Horwitz, & Kessler, 1982; Child Neurology Society, 1981). However, this classification of hyperlexia has not received support among professionals interested in dyslexia (e.g., McClure & Hynd, 1983) and is currently rarely used.

Hyperlexia as a subtype of language impairment

The view of hyperlexia as a subtype of developmental dyslexia has been challenged by a number of research reports and case studies (e.g., Cobrinik, 1974; Cohen et al., 1987; Goldberg & Rothermel, 1984; Healy et al., 1982; Huttenlocher & Huttenlocher, 1973; Mehegan & Dreifuss, 1972; Richman & Kitchell, 1981; Seymour & Evans, 1992; Temple, 1990), suggesting that language disorder is one of hyperlexia's essential features. As a result, Cohen et al. (1987) summarized the relevant research findings by stating that hyperlexia appears to be 'a variant of the semantic-pragmatic syndrome of developmental language disorder as described in the Child Neurology Nosology' (p. 27), rather than a variant of developmental dyslexia. The thrust of this proposition was in the observation that deficits in individuals with hyperlexia are not limited to written language (i.e., problems of comprehending written material), but extend into spoken language as well (i.e., problems of comprehending oral material). This proposition has been followed up in a comparative study of two groups with SLI, one with and one

without hyperlexia (Cohen, Hall, & Riccio, 1997). The results of this study registered few differences between the two groups, and only on those indicators that considered essential features of hyperlexia (specifically, significant group differences were found for visual/spatial memory and achievement indicators of word recognition, spelling, and arithmetic), thus suggesting a link between SLI and hyperlexia. One study does, however, suggest that, unlike most SLI individuals, at least a subgroup of individuals with hyperlexia (but without SLI diagnoses) have intact general language functions (e.g., Huttenlocher & Huttenlocher, 1973).

Hyperlexia as a central feature of reading comprehension disorder

It has been noted very early that children with hyperlexia demonstrate considerable difficulties with comprehension of printed material beyond (and often at) the single-word level. Given that, at least for some definitions, lower comprehension is central to hyperlexia (e.g., Rispen and VanBerckelaer (1991) refer to it as a striking fact of children with hyperlexia), it is surprising that so few researchers have addressed systematically the presence (or absence) of comprehension deficits in hyperlexia.

Mehegan and Dreifuss (1972) reported difficulties exhibited by individuals with hyperlexia with paraphrasing of the material read, and Richman and Kitchell (1981) reported suppressed levels of comprehension on standardized tests of reading. Kistner, Robbins, and Haskett (1988) described an autistic girl with hyperlexia who did not know the meaning of most words that she was able to decode perfectly. Three children with hyperlexia presented by Huttenlocher and Huttenlocher (1973) were able to respond to only very simple written commands. Similarly, children with hyperlexia described by Healy et al. (1982) were able to comprehend short literal sentences, but demonstrated very poor comprehension of larger chunks of text. Profound difficulties at the paragraph level were reported in children with hyperlexia by Goldberg and Rothermel (1984).

Snowling and Frith (1986) compared sentence- and larger-than-sentence units of reading comprehension in children with advanced decoding skills (mentally retarded autistic and non-autistic readers) to reading comprehension in younger nonretarded children matched for Mental and Reading Age. Of interest was that children across the whole sample were further subdivided into low and high verbal ability groups. A number of findings emerged from this work. First, the authors found that the knowledge of grammar in mentally retarded children was correlated with their vocabulary knowledge rather than their decoding skills. Second, it was reported that the most differentiating factor across all groups in terms of predicting the performance level on comprehension tasks was not that of mental age or

reading age, but that of the level of verbal ability. Finally, across all comprehension tasks used, mentally retarded autistic and non-autistic children were not distinguishable from each other; this finding challenges the idea that the skill of advanced decoding is autism-specific (i.e., 'hyperlexia is not a syndrome-specific phenomenon,' Snowling & Frith, 1986, p. 410). Summarizing their results, Snowling and Frith proposed a category of 'true hyperlexia' – a syndrome-independent condition, manifested as unexpected decoding success and unexpected comprehension failure defined with respect to the observed verbal ability. However, it is possible that the strict and limited nature of their label, which places a heavy accent on the decoding-comprehension discrepancy and almost ignores other features of hyperlexia (precocity and spontaneity of the emergence of the reading decoding skill and its obsessive character), explains the lack of difference between groups of children with autism and mental retardation.

There also has been some research on word-level comprehension. Specifically, a number of investigators have attempted to use lexical decision tasks in research with individuals with hyperlexia. The main obstacle in the administration of these tasks was the difficulty related to explaining instructions (e.g., Aram, Rose, & Horwitz, 1984). A few individuals with hyperlexia, however, were able to perform the task – those individuals were able to make most of the word-nonword decisions correctly (Goldberg & Rothermel, 1984), although the accuracy level was not remarkable. Aram, Ekelman, and Healy (1984), Goldberg and Rothermel (1984), and Temple and Carney (1996) did not find a discrepancy between single-word reading and word comprehension.

Another line of work has focused on whether depressed comprehension is exhibited in both oral and written modalities or only in the written modality. Comparison of reading and oral comprehension in individuals with hyperlexia has found no significant differences in that both types of comprehension were depressed (Aram, Rose, et al., 1984; Goodman, 1972; Healy et al., 1982; Huttenlocher & Huttenlocher, 1973; Temple, 1990).

It is relevant for the present discussion that such a continuum of discrepancy between students' abilities to read and to comprehend the material read was observed in the early 1930s (Manroe, 1932), although at that point the term 'hyperlexia' was not used; since the late 1960s and even more so now, the central feature of hyperlexia (the discrepancy between decoding and comprehension) is often referred to as the central feature of 'reading comprehension disorder.' Although this 'disorder' has not made it into diagnostic manuals, the literature on it has been developing rather rapidly. Since the issue of comprehension disorder, its existence, and its merit as an independent diagnostic category is not central to

this annotation, we stress only the following findings from the literature. First, although often referred to as a reading disorder, comprehension disorder emerges (and, therefore, becomes diagnosable) only by middle school (e.g., Leach & Scarborough, in press). Second, it appears that children with comprehension difficulties have a neuropsychological profile distinctly different from that of children with developmental dyslexia (e.g., Nation, 2001; Nation & Snowling, 1998a, b, 1999, 2000; Snowling, 2002). Finally, it appears that whether defined through the discrepancy between single-word recognition and vocabulary (e.g., van Daal & Miles, 2001) or single-word recognition and reading comprehension (e.g., Grigorenko & Katz, 2003), comprehension deficit is observed comparably as often as developmental dyslexia in the general population.

In other words, when defined through the discrepancy between single-word reading and comprehension (either at the word level through indicators of vocabulary or at the higher-than-word level of connected text), in the general population, the concept of hyperlexia becomes indistinguishable from the concept of reading comprehension disorder.

Hyperlexia as a subtype of PDD

Another line of work has focused on the link between autism spectrum disorders (ASD)/pervasive developmental disorder (PDD) and hyperlexia (e.g., Eisenberg & Kanner, 1956; Needleman, 1982; Parker, 1919; Phillips, 1930; Smith & Bryson, 1988; Tirosh & Canby, 1993; Whitehouse & Harris, 1984). This line of thinking is connected to the early writings of Kanner (1943) in which he described exceptional reading skills in some of his patients with autism, both boys and girls. The frequency of hyperlexia, estimated in a few isolated studies, appears to be 5–10% among PDD individuals (e.g., Burd & Kerbeshian, 1985). There is evidence from case studies (e.g., Patti & Lupinetti, 1993; Siegel, 1984) and group studies (e.g., Grigorenko et al., 2002), indicating higher frequency of hyperlexia among children with the diagnosis of PDD than among children with a variety of other conditions who have been referred to clinics because of developmental delays of various natures. This line of work seems to imply that there may be something specific about developmental social disabilities such as autism that may foster hyperlexic skills or, at least, that there is a meaningful association between PDD and hyperlexia.

In addition to a lack of agreement on hyperlexia as a subtype or a symptom of developmental dyslexia, SLI, or PDD, the 'belonging' of hyperlexia to a specific diagnostic category has been challenged by a number of studies describing hyperlexia in cases diagnosed with some other disorders. Specifically, hyperlexia has been observed in individuals with Turner Syndrome (Temple & Carney, 1996), Tourette Syndrome (Burd & Kerbeshian, 1988), and various

forms of mental retardation (Fontenelle & Alacron, 1982; Mehegan & Dreifuss, 1972; Worthy & Invernizzi, 1995). While the value of case studies is intrinsically limited, the range of disorders associated with hyperlexia has been taken to suggest that it might best be regarded as a rather nonspecific, cross-diagnostic phenomenon (Goldberg, 1987; Graziani et al., 1983; Healy, 1982; Needleman, 1982; Snowling & Frith, 1986; Whitehouse & Harris, 1984) that should be referred to as the syndrome of hyperlexia (Healy, 1982). However, in all these instances of observing hyperlexia in 'other than PDD' conditions, hyperlexia was viewed as a discrepancy between reading words and understanding words and connected text (i.e., as a reading comprehension disorder). Thus, is it not 'handier' and less terminologically confusing to use the concept of 'reading comprehension disorder' to refer to nonspecific discrepancies between single-word reading and comprehension and preserve the concept of hyperlexia for a specific symptom observed among children in the PDD-spectrum? Equating hyperlexia with reading comprehension disorder, from our point of view, eliminates the uniqueness of this phenomenon, of which the reading decoding-comprehension gap is only one of many facets. Other facets capture almost obsessive interest in letters and words, precocity and spontaneity of the emergence of the skill of decoding letters into sounds, and the degree of discrepancy between reading decoding and other cognitive skills.

Hyperlexia: advanced word recognition with regard to what?

As indicated above, the definition of hyperlexia assumes the presence of an excess of single-word reading ability with respect to what is expected of an individual based on something else. This question of what the something else should be has been controversial. Silberberg and Silberberg (1967) initially suggested that the comparison be made to word comprehension or verbal functioning level. Later, however, they suggested that the discrepancy should be drawn between a child's expected and observed reading levels based on their chronological and reading age, respectively; they even specified the discrepancy as 1 year in grades one, two, and three, and 1.5 years in grades thereafter (Silberberg & Silberberg, 1968-69) and later changed it to 1.5 years in grades one and two and 2 years in grades thereafter (Silberberg & Silberberg, 1971). Niensted (1968), working in typical schools, also used a 1-year discrepancy criterion and ended up calling 58% of her sample 'hyperlexic.'

Currently, there are three major positions with regard to the discrepancy criteria in hyperlexia. According to the first position (e.g., Temple & Carney, 1996), the discrepancy should be nonspecific, that is, between the level of word identification and the level

of other cognitive functions (mostly measured as IQ in some form). According to the second position, the discrepancy should be specific, that is, between the level of word identification and comprehension (e.g., Nation, 1999). The third position is a merging of the two, suggesting that the definition of hyperlexia should rest on a double discrepancy – word identification skills should be higher than expected based on general developmental level, and comprehension should be lower than expected based on word identification skills (Rispen & Berckelaer, 1991; Snowling & Frith, 1986).

In our work (Grigorenko et al., 2002), we have used a strict definition of hyperlexia based on a discrepancy between word-level decoding and comprehension. In this interpretation (again, given that hyperlexia is viewed as a PDD-specific phenomenon), we try to preserve the uniqueness of the term and the behaviors described by this term.

Hyperlexia and other psychological processes

Of the issues addressed in this commentary the most controversial is that of a general process-based description of hyperlexic functioning. A series of descriptive and experimental studies have addressed this issue.

First, the major source of clinical cases believed to exhibit hyperlexia are referred for evaluations of *language delays*; commonly mentioned delays include delays in using single words and connected sentences; onset of using several single words; and onset of speech after or coincident with identification of words, spelling of words, or reading aloud (Aram, Rose, et al., 1984; Elliott & Needleman, 1976; Goldberg & Rothermel, 1984; Goodman, 1972; Healy et al., 1982). Most reports also note depressed oral comprehension (Aram, Rose, et al., 1984; Cobrinik, 1974; Richman & Kitchell, 1981). Children with hyperlexia have been shown to have grammatical difficulties (e.g., Healy et al., 1982) and difficulties with the use of expressive language (e.g., Cobrinik, 1974; Fontenelle & Alarcon, 1982; Mehegan & Dreifuss, 1972). Although some reports mention impaired prosody (e.g., Cobrinik, 1982; Healy et al., 1982; Goldberg & Rothermel, 1984), others have found no prosodic irregularities (e.g., Aram, Rose, et al., 1984).

A second convergent line of evidence indicates the presence of *social difficulties* and atypical social behavior in individuals with hyperlexia, although social behaviors reported in these individuals range widely, from pronounced autism to limited interpersonal skills and poor eye contact (Healy et al., 1982).

There is also a substantial body of divergent evidence with regard to a holistic characterization of the phenomenon of hyperlexia. Given that the definition of hyperlexia, at least in one of its forms, refers to the

discrepancy between word recognition and IQ, the presence of this gap is assumed, but the absolute value of IQ is not specified. In fact, individuals with hyperlexia have been shown to demonstrate a wide spread of IQ (e.g., Grigorenko et al., 2002). With respect to IQ's components, the majority of studies report higher scores on performance IQ than verbal IQ demonstrated by individuals with hyperlexia (e.g., Cobrinik, 1974; Goldberg & Rothermel, 1984), although one study reports the opposite pattern (Fontenelle & Alarcon, 1982) and a few studies have reported generalized deficits in both verbal and performance areas (e.g., Healy et al., 1982).

A number of descriptive studies have mentioned unusual patterns of *motor skills* in children with hyperlexia (e.g., Cobrinik, 1982; Huttenlocher & Huttenlocher, 1973). Usually mentioned is the presence of unusual and repetitive movements, a feature potentially consistent with the finding of higher rates of PDD. There is also some mention of motor development delays; this evidence, however, is contradictory (e.g., Goldberg & Rothermel, 1984; Healy et al., 1982).

Two studies have examined the links between hyperlexia and acquisition of a foreign language. LeBrun, Van Endert, and Sziwowski (1988) presented a case where an adolescent girl with hyperlexia could read aloud words in three languages (Dutch, English, and French). The girl could read the words more effectively and with better pronunciation than she could use them in her spontaneous speech. Sparks and Artzer (2000) presented a child with hyperlexia who was enrolled in a foreign language course (Spanish). The child was able to go through two years of Spanish and exhibited adequate word recognition skills in Spanish (significantly lower compared to his English word recognition skills) and performed word-level tasks better than any tasks that required comprehension of sentences and larger units of text. In both cases the children demonstrated the same 'hyperlexic' profile of discrepancy between word recognition and comprehension in all languages they functioned in.

Finally, there is a disagreement in the literature with regard to references to the presence of various *special abilities* in individuals with hyperlexia. For example, superior visual discrimination abilities have been reported in several case studies (e.g., Cobrinik, 1982; Goodman, 1972; Healy et al., 1982), but negated in others (e.g., Siegel, 1984). Some researchers have reported exceptional date calculation abilities (e.g., Smith, 1988), whereas others reported remarkable memory for special information such as dates of US presidents or street names (e.g., Aram, Rose, et al., 1984; Cain, 1969; Goodman, 1972; Mehegan & Dreifuss, 1972). Exceptional, but circumscribed, musical talents have also been noted (e.g., Aram, Rose, et al., 1984). Again such reports potentially suggest a link to PDD.

In sum, there is currently no distinct neuropsychological profile associated with hyperlexia. An issue here, of course, is that if the field does not converge on the general definition of hyperlexia, it is difficult for the field to agree on specific aspects of this phenomenon.

Hyperlexia: the developmental profile

Jane Healy (1982) was one of the first hyperlexia researchers to press the notion that, developmentally, hyperlexia is characterized by both spontaneous (self-taught) and early emergence, as well as a persistent unfolding of advanced single-word reading. She wrote that such advanced word recognition is typically observed before the age of 5 and often by the age of 3. Healy (1982), along with other authors (Aron, 1989; Aram, 1997; Aram & Healy, 1988; Healy et al., 1982), also stressed the presence of both obsessive preoccupation with and pleasure from written stimuli, experienced by children with hyperlexia not only at the emergence of the reading skills, but throughout their lives, often overshadowing and even forcing out developmentally appropriate activities.

A number of longitudinal studies of children with hyperlexia have been conducted to date. These include both case (e.g., Glosser, Friedman, & Roeltgen, 1996; Siegel, 1984, 1994) and group studies (e.g., Burd, Fisher, Knowlton, & Kerbeshian, 1987; Sparks, 2001; Whitehouse & Harris, 1984). Although most of these children continued to demonstrate advanced decoding skills throughout their life span, often the absolute values on the corresponding tests were at the same level or lower than at the moment of initial evaluation and the diagnosis of hyperlexia. In other words, the word recognition skill, central to hyperlexia, remains stable or declines over time (e.g., Siegel, 1994; Sparks, 2001). However, it has been observed that comprehension in children with hyperlexia remains impaired over time (e.g., Sparks, 2001). Thus, mostly the initial gap between the levels of word recognition and comprehension is closing developmentally not because of improvement in comprehension, but because of the decay or lack of further progress in word-recognition skills. Yet, another interesting observation is that, growing up, a number of children with hyperlexia appear to be losing their passion for reading (Sparks, 2001). The question of why these children might lose their ardor for reading is an extremely interesting one. It is possible that, early in atypical development, symbols such as letters offer a sense of organization and coherence to a child who is otherwise overwhelmed by a social world that is confusing, perplexing, and difficult to interpret. Yet, later, with appropriate interventions, this 'need for interpretability and structure' might become less daunting, replacing the passion for the printed symbols with less distinct, but satisfactory activities. In accord-

ance with this interpretation is the observation that, although some early reports (e.g., Burd et al., 1987) suggested that hyperlexia might be a positive factor, enhancing the developmental outcome of children with PDD, these reports have not been confirmed by an independent group of investigators. For example, in our work (Grigorenko et al., 2002), we did not register better outcomes of PDD children with hyperlexia as compared to children with PDD, but no hyperlexia.

A number of case studies have attempted to investigate the motivational structure beyond the observed fascination with printed stimuli exhibited by individuals with hyperlexia. For example, Bryson, Landry, and Smith (1994) have arrived at the conclusion that an autistic girl with hyperlexia they observed 'appeared interested in print for its own sake' (p. 229). Unfortunately, to our knowledge, there have been no studies investigating the change of motivation and drive to attend to printed word in children with hyperlexia over a significant period of time. Thus, although researchers acknowledge the presence of this 'passion for printed word' as one of the key features of hyperlexia, there is no systematic information regarding how this drive emerges, how long it stays, and whether and/or when it disappears.

The biological signature of hyperlexia

In their 1967 article, Silberberg and Silberberg raised the question of whether the ability to recognize words represents some kind of a distinct, biologically rooted familial trait (a physiological variant with familial component). Although intriguing at the first glance, this hypothesis surprisingly has never been examined systematically. Very few studies have addressed the issue of familial links in hyperlexia. For example, Whitehouse and Harris (1984) presented a sibling pair, both with hyperlexia and autism, one retarded and one not. Smith and Bryson (1988) reported a monozygotic twin pair, concordant for autism and hyperlexia. Moreover, there have been some suggestions of familial links between hyperlexia and dyslexia. Specifically, in a study of 12 hyperlexic PDD probands, Healy et al. (1982) discovered that reading disorders on the paternal side of hyperlexics were found in 11 of the 12 families studied. In contrast to this lack of research regarding the familial links of hyperlexia, the familial nature of dyslexia is well established. Moreover, there is strong evidence suggesting that reading-related cognitive processes are highly heritable in both dyslexic and normal populations.

Yet another understanding of hyperlexia is that this phenomenon is an outcome of a certain type of reading instruction. Niensted (1968), using a minimum 1-year discrepancy between reading word lists and silent comprehension, surveyed children attending schools in which reading was taught

differently (primarily phonics-oriented versus embedding phonics in a basal reading program) and reported a higher number of children with hyperlexia in a school where reading was taught with strong emphasis on phonics. Niensted then conducted a pedagogical experiment having shared strategies for improving comprehension with teachers and parents from the phonics-based school; having retested the children in this school later, she registered a lower, compared to the baseline, level of hyperlexia. The interpretation was that 'hyperlexia can be overcome through education' (Niensted, 1968, p. 163).

Although the literature on the etiology of hyperlexia is very limited, the literature on the etiology of single-word processing is overwhelmingly rich. Moreover, at this point, it is widely accepted that single-word reading is a biologically rooted (e.g., Cabeza & Nyberg, 2000) and etiologically complex process emerging under influences of both genetic and environmental factors (for review, see Grigorenko, 2001), whose neuroanatomical bases change across life span (Schlaggar et al., 2002). Therefore, it is plausible that the etiology of hyperlexia is, at least partially, biological. The challenge is in determining its mechanism and the degree to which it is or can be influenced by environmental factors.

Thus, at this point, we simply do not know enough to make a conclusive statement about the etiology of hyperlexia. Clearly, more work in this domain needs to be done so that the field can arrive at better informed hypotheses.

Hyperlexia and typical reading: are the mechanisms comparable?

The specifics of the reading process in individuals with hyperlexia are of particular interest. The main question here is whether single-word reading exhibited by individuals with hyperlexia is 'typical' reading or is reading based on a specific type. DeHirsch (1971) was the first to introduce the hypothesis that the mechanism behind hyperlexia was in visual memorization of whole words. Cobrinik (1982) also assumed that hyperlexic reading is exclusively visual and implemented this assumption in an experimental study. Specifically, a series of degraded 7-to-9-letter familiar words were presented to 9 hyperlexic boys and 10 control subjects. The groups were age-matched, but the children with hyperlexia had significantly lower levels of IQ and Wide Range Achievement Test Word Recognition scores. The results indicated that boys with hyperlexia deciphered the incomplete words significantly faster and more accurately than the controls, suggesting that word recognition in hyperlexia is based primarily on pattern recognition. A number of case studies further support this assertion (e.g., Bryson et al., 1994). Subsequently, Goldberg and Rothermel (1984) showed that hyperlexic word recognition is

also based on orthographic patterning. Specifically, these researchers have created a battery of words whose presentation was visually deviant through a number of modifications – case, orientation, linearity, spacing, and an addition of irrelevant symbols. Only irrelevant symbols impacted the reading speed in children with hyperlexia; otherwise, the word identification remained rather intact. Similarly, there are case descriptions indicating the efficient functioning of orthographic systems in individuals with hyperlexia (e.g., Glosser et al., 1996; Glosser, Grugan, & Friedman, 1997; Seymour & Evans, 1992). Thus, it appears that hyperlexic reading is not exclusively based on visual memory and involves, at least to some degree, some symbol mapping and decoding.

Further, the ‘exclusively visual’ mechanism of hyperlexia has been challenged by a number of studies that have registered a presence of exceptional decoding skills of unfamiliar (nonsense) words in children with hyperlexia (e.g., Healy, 1982; Needleman, 1982; Siegel, 1984). There appears to be more similarity between typical and hyperlexic reading than was initially expected: Evidently, individuals with hyperlexia rely on phonemic processing while identifying single words. For example, individuals with hyperlexia make fewer errors in regular than in exceptional words, just as typical readers do (Aram, Ekelman, et al., 1984; Aram, Rose, et al., 1984; Frith & Snowling, 1983; Goldberg & Rothermel, 1984). Of note is that one of the children described by Kanner (1943) had an exceptional interest in ‘rhymes or things of this nature’ (p. 217). Frith and Snowling (1983) showed that children with hyperlexia were able to recognize words using visual/orthographic and phonological strategies equally well. Of interest, however, are the findings of Cossu and Marshall (1986), indicating that the advancement in decoding skills does not necessarily correspond to the advancement in phonological processing (referred to by Cossu and Marshall as metalinguistic) skills. The two cases with hyperlexia presented by these researchers showed remarkable performance on reading and writing tasks in the presence of poor performance on a variety of tasks on verbal memory and phonological tasks. Thus, although phonological mechanisms are utilized in hyperlexic reading, advanced decoding does not necessarily co-occur with advanced phonological processing, at least on selected tasks (Cossu & Marshall, 1986; Kennedy, 2002; Sparks, 1995, 2001). However, the apparent similarities between hyperlexic and typical reading suggest that children with hyperlexia are not just ‘barking at print’ (Snowling & Frith, 1986, p. 393); they appear to be identifying and decoding words in a fashion similar to that of normal readers.

Finally, there is also mixed evidence with regard to the utilization, by children with hyperlexia, of the phoneme–grapheme correspondence rules, which are considered to be one of the major mechanisms of the development of typical reading. Similarly to the

issues discussed above, there is some evidence suggesting that at least some hyperlexic reading is attributable to the mastery of the phoneme–grapheme conversion rule (e.g., O’Connor & Hermelin, 1994); others do not find any support for this assertion (e.g., Cobrinik, 1982) or present evidence supporting the utilization of both phonological and visual routes of word recognition (e.g., Kennedy, 2002; Welsh, Pennington, & Rogers, 1987).

In sum, it is important to notice that there is contradictory evidence in the literature with regard to ‘other’ processes that typically highly correlate with word identification: The literature, in general, points out the presence of variability in decoding nonwords among individuals with hyperlexia (e.g., Aram, Ekelman, et al., 1984), tests of memory (e.g., Kistner et al., 1988), a variety of phonological processes (e.g., Sparks, 1995, 2001), and comprehension (e.g., Frith & Snowling, 1983). Thus, the existence of various subtypes of hyperlexia is possible.

To explore the hypothesis of subtypes in hyperlexia, Richman and Wood (2002) studied 30 boys (6–13 years of age) with hyperlexia. The children were identified through a set of criteria including parental reports of precocious reading, atypical (not necessarily impaired) language development, atypical social interaction, a significant discrepancy between reading level and IQ, a significant (at least 2 years) discrepancy between single-word reading and reading comprehension. Based on the children’s performance on a battery of neuropsychological tests, children with hyperlexia were classified into three groups: (1) language-learning disabilities; (2) nonverbal learning disabilities; and (3) mixed learning disabilities. Because group 3 was very small (3 children), it was deleted from further analyses. When groups 1 and 2 were compared on indicators of phonological processing and visual memory, the first group (language-learning disabilities group) demonstrated good visual memory skills; but they exhibited a higher number of phonetic errors and a lower level of comprehension than did the nonverbal-learning disabilities group. In contrast, the second group (nonverbal learning disabilities) demonstrated deficits in the visual-spatial domain but fewer phonetic errors and a higher level of comprehension.

In summary, it is possible that somewhat contradictory findings with regard to mechanisms of hyperlexia can be explained by the existence of different pathways to advanced decoding – apparently, superior word recognition can be achieved both through primarily visual and primarily phonological pathways.

Hyperlexia: deficit or talent? Disability or superability?

Silberberg and Silberberg (1967) referred to hyperlexia as ‘a specific talent or group of talents’ (p. 41),

stressing its apparent independence from levels of general functioning and hypothesizing hyperlexia's underlying basis as a 'neurological precocity' (p. 41). Such an approach to hyperlexia is similar to viewing it as a savant ability to recognize single words. Some researchers have widened the definition of hyperlexia, incorporating into this phenomenon preoccupation with both letters and numbers (DeLong, Ritch, & Burch, 2002). From this point of view, hyperlexia is a talent – a unique gift to a rather unfortunate child suffering from a developmental disability.

Another possibility is to view hyperlexia as a reading-comprehension disorder. Then, when apparent in children with PDD, it can be simply described as a comorbid condition of comprehension disorder. In this context, hyperlexia is not a superability, but rather a specific disability with a particular signature. Similar to dyslexia, where disability is described through a discrepancy between vocabulary (or general ability) and single-word reading, comprehension disorder is defined on the basis of a 'reversed' discrepancy – that where single-word skills are strong, comprehension skills are weak. If dyslexia is viewed as disability, then hyperlexia (defined as comprehension disorder) should also be viewed as a disability.

There is an emerging literature that takes the phenomenon of hyperlexia out of the cognitive domain where it has been placed, and puts it in the domain of social disabilities (e.g., Klin, Chawarska, Ruben, & Volkmar, in press). From this point of view, hyperlexia might be a precocious skill, marking a reduced early developmental ability to make sense of other stimuli available in the environment, especially social stimuli. Interpreted in this way, hyperlexia is a form of social disability or, at least, a precursor of an emerging social disability. What is implicit in this interpretation is the developmental significance of hyperlexia, indicating a 'different' style of interpreting early-life stimuli (fascination with stable, unchanging, constantly interpretable printed symbols and fear of changing, fluid, constantly calling for an interpretation social stimuli). This view might explain the fact of 'disappearing' hyperlexia in development. Helping a child learn how to manage social stimuli might dilute his obsession with printed stimuli.

Yet another possibility is to view hyperlexia in the context of the distribution of single-word reading skill in the general population. Snowling and Frith (1986) stated that the very existence of hyperlexia is a principal argument for the possibility of the formation of a functional word-decoding system independent (or semi-independent) of connections to the systems of syntactic, semantic, and general knowledge. These four systems (decoding, grammar, meaning, and general knowledge) are highly correlated in typical readers and appear not to correlate in hyperlexic children. Two issues need to be

mentioned in this context. First, the assumption (and even proof) of the modularity of the decoding system does not explain the emergence of hyperlexia and does not address the question of deficit or talent. The issue here is that, if compared to the distribution of word-recognition skill in the general population, even when age-corrected, children with hyperlexia do not score very high. When they do, they show their superiority early in development and lose it later in development. Second, it is unclear why the word recognition–word comprehension discrepancy arises. It might arise because of the advantage of the word-recognition modular system as well as the disadvantage of the meaning system. In fact, hyperlexia can be interpreted as half-baked (or half-unfolded) formation of reading skills, in which decoding skills are in place, but the system does not know how to build semantic networks to finish the construction of the reading system.

In summary, although the phenomenon of hyperlexia is of obvious interest, several factors complicate the interpretation of available data. First, there is disagreement over whether hyperlexia is a symptom of a more general syndrome (e.g., PDD) or whether it is a cross-diagnostic phenomenon. Second, there is no agreement on whether it is a phenomenon circumscribed to clinical populations or extendable to the general population. Third, although there is agreement that the core of hyperlexia is the process of word recognition, there are various opinions on how this process should be evaluated compared to the level of general cognitive functioning, the level of comprehension, the level of vocabulary, or any combination of these. Fourth, there is more agreement on the weaknesses exhibited by individuals with hyperlexia than on their relative strengths. Finally, it is unclear whether hyperlexia can be explained through processes subserving 'typical' reading or whether hyperlexic reading is etiologically different.

Clearly, some of these issues are related, and taking a position within one line of argument helps to constrain the positions one may take regarding the others. For example, if we assume that hyperlexia is a specific symptom exhibited by individuals with PDD, this would (1) restrict hyperlexia to clinical samples; (2) rule out the necessity to make references to the level of comprehension, because among PDD individuals, levels of both oral and written comprehension are highly correlated with levels of general intellectual functioning; (3) view word recognition as an isolated skill preserved in individuals with PDD and developed by them into a superability (relative to their other cognitive functions), perhaps as a result of deliberate (often obsessive) practice; and (4) imply that the general underlying model of word recognition is the same for 'typical' and hyperlexic reading. This view would posit, therefore, that hyperlexia is a superability demonstrated by a very specific group of individuals with developmental disorders (defined through unexpected word recognition in the context

of otherwise suppressed intellectual functioning) rather than as a disability exhibited by a portion of the general population (defined through a discrepancy between the levels of word recognition and comprehension). Taking such a stance narrows the field of study; but it does not address major questions in need of clarification, including why hyperlexia should be more commonly associated with PDDs rather than other conditions. This stance also prematurely reduces discussion of processes that are still poorly understood, including the onset, developmental trajectory, and neuropsychology of reading and decoding skills in individuals with PDD vis-à-vis typically developing populations.

Another approach might be to treat hyperlexia within the research framework aimed at understanding single-word recognition, thus submitting it to the various available methodologies in that field, including external validity studies of different definitions (Pennington, Gilger, Olson, & DeFries, 1992), prospective/longitudinal studies (Bishop & Adams, 1991), genetic studies (Hohnen & Stevenson, 1999), experimental studies (e.g., eye-tracking paradigms; Trueswell, Sekerina, Hill, & Logrip, 1999), and functional neuroimaging studies (Shaywitz, Shaywitz, Pugh, & Skudlarski, 1996). Although we clearly are proponents of this multifaceted approach, we still strongly promote the view of hyperlexia as a PDD-specific phenomenon. Even when hyperlexia is studied within the context of reading, from our point of view, it should be studied in children with PDD. Otherwise, as soon as we exit the limiting brackets of the diagnoses of PDD, we inevitably enter the domain of terminological confusion. We become unable to differentiate the concept of hyperlexia from the concept of comprehension disorder (as both are currently defined with respect to the general population).

If studied in the context of PDD, the power necessary for such studies would be assembled through collaborative projects not unlike the ones that have furthered our understanding of reading so much in the past decade. This is true despite the fact that hyperlexia is still considered a rather rare phenomenon.

Acknowledgment

The preparation of this article was, in part, supported by the grant from the Cure Autism Now Foundation to ELG. We want to thank Robyn Rissman for valuable editorial comments and Tina Newman and Donna Macomber for critical evaluation of the content of the annotation.

Correspondence to

Elena L. Grigorenko, Yale Child Study Center, 230 South Frontage Road, New Haven, CT 06510, USA; Email: elena.grigorenko@yale.edu

References

- Aaron, P.G. (1989). *Dyslexia and hyperlexia*. Boston, MA: Kluwer Academic Publishers.
- Aram, D. (1997). Hyperlexia: Reading without meaning in young children. *Topics in Language Disorders*, 7, 1–13.
- Aram, D.M., Ekelman, B.L., & Healy, J.M. (1984, June). *Reading profiles of hyperlexic children*. Paper presented at the meeting of the International Neuropsychology Society, Aachen, West Germany.
- Aram, D.M., & Healy, J.M. (1988). Hyperlexia: A review of extraordinary word recognition. In L. Obler & D. Fein (Eds.), *Neuropsychology of talent* (pp. 70–102). New York, NY: Guilford.
- Aram, D.M., Rose, D.F., & Horwitz, S.J. (1984). Hyperlexia: Developmental reading without meaning. In R.M. Joshi & H.A. Whitaker (Eds.), *Dyslexia: A global issue* (pp. 518–533). The Hague: Martinus Nijhoff.
- Bender, L. (1955). Twenty years of clinical research on schizophrenic children. In G. Caplan (Ed.), *Emotional problems of early childhood*. New York: Basic Books.
- Benton, A.L. (1978). Some conclusions about dyslexia. In A.L. Benton & D. Pearl (Eds.), *Dyslexia: An appraisal of current knowledge* (pp. 37–59). New York: Oxford University Press.
- Bergman, P., & Escalona, S. (1948). Usual sensitivities in very young children. *Psychoanalytic Study of the Child*, 3–4, 333–352.
- Bishop, D.V., & Adams, C. (1991). A prospective study of the relationship between specific language impairment, phonological disorders and reading retardation. *Journal of Child Psychology and Psychiatry*, 31, 1027–1050.
- Bryson, S.E., Landry, R., & Smith, I.M. (1994). Brief report: A case study of literacy and socioemotional development in a mute autistic female. *Journal of Autism and Developmental Disorders*, 24, 225–231.
- Burd, L., Fisher, W., Knowlton, D., & Kerbeshian, J. (1987). Hyperlexia: A marker for improvement in children with pervasive developmental disorder? *Journal of American Academy of Child and Adolescent Psychiatry*, 26, 407–412.
- Burd, L., & Kerbeshian, J. (1985). Inquiry into the incidence of hyperlexia in a statewide population of children with Pervasive Developmental Disorder. *Psychological Reports*, 57, 236–238.
- Burd, L., & Kerbeshian, J. (1988). Familial pervasive development disorder, Tourette disorder, and hyperlexia. *Neuroscience and Biobehavioral Reviews*, 12, 233–234.
- Cabeza, R., & Nyberg, L. (2000). Imaging cognition II: An empirical review of 275 PET and fMRI studies. *Journal of Cognitive Neuroscience*, 12, 1–47.
- Cain, A.C. (1969). Special 'isolated' abilities in severely psychotic young children. *Psychiatry*, 32, 137–149.
- Cobrinik, L. (1974). Unusual reading ability in severely disturbed children. *Journal of Autism and Childhood Schizophrenia*, 4, 163–175.
- Cobrinik, L. (1982). The performance of hyperlexic children on an 'incomplete words' task. *Neuropsychology*, 20, 569–577.
- Cohen, M.J., Campbell, R.C., & Gelardo, M. (1987). Hyperlexia: A variant of aphasia or dyslexia. *Pediatric Neurology*, 3, 22–28.

- Cohen, M.J., Hall, J., & Riccio, C.A. (1997). Neuropsychological profiles of children diagnosed as specific language impaired with and without hyperlexia. *Archives of Clinical Neuropsychology*, 12, 223-229.
- Cossu, G., & Marshall, J.C. (1986). Theoretical implications of the hyperlexia syndrome: The new Italian cases. *Cortex*, 22, 579-598.
- Crain-Thoreson, C., & Dale, P.S. (1992). Do early talkers become early readers? Linguistic precocity, preschool language, and emergent literacy. *Developmental Psychology*, 28, 421-429.
- DeHirsch, K. (1971). Are hyperlexics dyslexic? *The Journal of Special Education*, 5, 243-246.
- DeLong, G.R., Ritch, C.R., & Burch, S. (2002). Fluoxetine response in children with autistic spectrum disorders: Correlation with familial major affective disorder and intellectual achievement. *Developmental Medicine and Child Neurology*, 44, 652-659.
- Eisenberg, L., & Kanner, L. (1956). Early infantile autism, 1943-1955. *American Journal of Orthopsychiatry*, 26, 556-566.
- Elliott, D.E., & Needleman, R.M. (1976). The syndrome of hyperlexia. *Brain and Language*, 3, 339-349.
- Fontenelle, S., & Alarcon, M. (1982). Hyperlexia: Precocious word recognition in developmentally delayed children. *Perceptual and Motor Skills*, 55, 247-252.
- Frith, U., & Snowling, M. (1983). Reading for meaning and reading for sound in autistic and dyslexia children. *British Journal of Developmental Psychology*, 1, 329-342.
- Glosser, G., Friedman, R.B., & Roeltgen, D.P. (1996). Clues to cognitive organization of reading and writing from developmental hyperlexia. *Neuropsychology*, 10, 168-175.
- Glosser, G., Grugan, P., & Friedman, R.B. (1997). Semantic memory impairment does not impact on phonological and orthographic processing in a case of developmental hyperlexia. *Brain and Language*, 56, 234-247.
- Goldberg, T.E. (1987). On hermetic reading abilities. *Journal of Autism and Developmental Disorders*, 17, 29-44.
- Goldberg, T.E., & Rothermel, R.D. (1984). Hyperlexic children reading. *Brain*, 107, 759-785.
- Goodman, J. (1972). A case study of an autistic savant: Mental function in the psychotic child markedly discrepant abilities. *Journal of Child Psychology and Psychiatry*, 13, 267-278.
- Graziani, L.J., Brodsky, K., Mason, J.C., & Cager, R.P. (1983). Variability in IQ scores and prognosis of children with hyperlexia. *Journal of the American Academy of Child Psychiatry*, 22, 441-443.
- Grigorenko, E.L. (2001). Developmental dyslexia: An update on genes, brains, and environments. *Journal of Child Psychology and Psychiatry*, 42, 91-125.
- Grigorenko, E.L., & Katz, L. (2003). *Types of reading difficulties in Russian*. Unpublished manuscript.
- Grigorenko, E.L., Klin, A., Pails, D.L., Sent, R., Hooper, C., & Volkmar, F. (2002). A descriptive study of hyperlexia in a clinically referred sample of children with developmental delays. *Journal of Autism and Developmental Disorders*, 32, 3-11.
- Healy, J.M. (1982). The enigma of hyperlexia. *Reading Research Quarterly*, 17, 319-338.
- Healy, J.M., & Aram, D.M. (1986). Hyperlexia and dyslexia: A family study. *Annals of Dyslexia*, 36, 226-253.
- Healy, J.M., Aram, D.M., Horwitz, S.J., & Kessler, J.W. (1982). A study of hyperlexia. *Brain and Language*, 9, 1-23.
- Hohnen, B., & Stevenson, J. (1999). The structure of genetic influences on general cognitive, language, phonological, and reading abilities. *Developmental Psychology*, 35, 590-603.
- Huttenlocher, P.R., & Huttenlocher, J.A. (1973). A study of children with hyperlexia. *Neurology*, 23, 1107-1116.
- Jackson, N.E. (1992). Precocious reading of English: Origins, structure, and predictive significance. In P.S. Klein & J. Tannenbaum (Eds.), *To be young and gifted* (pp. 171-203). New Jersey: Ablex.
- Jackson, N.E., & Biemiller, A.J. (1985). Letter, word, and text reading times of precocious and average readers. *Child Development*, 56, 196-206.
- Jackson, N.E., Donaldson, G.W., & Cleland, L.N. (1988). The structure of precocious reading ability. *Journal of Educational Psychology*, 80, 234-243.
- Kanner, L. (1943). Autistic disturbances of affective contact. *Nervous Child*, 21, 217-250.
- Kennedy, B. (2002). Hyperlexia profiles. *Brain and Language*, 84, 204-221.
- Kistner, J., Robbins, F., & Haskett, M. (1988). Assessment and skill remediation of hyperlexia children. *Journal of Autism and Developmental Disorders*, 18, 191-205.
- Klin, A., Chawarska, K., Rubin, E., & Volkmar, F.R. (in press). Clinical assessment of toddlers at risk of autism. In R. DelCarmen-Wiggins & A. Carter, *Handbook of infant and toddler mental health assessment*. Oxford: Oxford University Press.
- Kupperman, P. (1997). Precocious reading skills may signal hyperlexia. *The Brown University Child and Adolescent Behavior Letter*, 13, 2-4.
- Leach, J.M., & Scarborough, H.S. (in press). Late-emerging reading disabilities. *Journal of Educational Psychology*.
- LeBrun, Y., Van Endert, C., & Sziwowski, H. (1988). Trilingual hyperlexia. In L.K. Obler & D. Fein (Eds.), *The exceptional brain* (pp. 253-264). New York: Guilford Press.
- Mahler, M.S., & Elkisch, P. (1953). Some observations on disturbances of the ego in a case of infantile psychosis. *Psychoanalytic study of the child: Vol. 8*. New York: International University Press.
- Manner, I. (1943). Autistic disturbances of affective contact. *Nervous Child*, 2, 217-250.
- Manroe, M. (1932). *Children who cannot read*. Chicago, IL: University of Chicago Press.
- McClure, P.H., & Hynd, G.W. (1983). Is hyperlexia a severe reading disorder or a symptom of psychiatric disturbance? Nosological considerations. *Clinical Neuropsychology*, 4, 145-149.
- Mehegan, C.C., & Dreifuss, F.E. (1972). Hyperlexia. *Neurology*, 22, 1105-1111.
- Nation, K. (1999). Reading skills in hyperlexia: A developmental perspective. *Psychological Bulletin*, 125, 338-355.
- Nation, K. (2001). Exposing hidden deficits (Spearman Medal Lecture). *The Psychologist*, 14, 238-242.

- Nation, K., & Snowling, M.J. (1998a). Individual differences in contextual facilitation: Evidence from dyslexia and poor reading comprehension. *Child Development, 69*, 996–1011.
- Nation, K., & Snowling, M.J. (1998b). Semantic processing and the development of word recognition skills: Evidence from children with reading comprehension difficulties. *Journal of Memory and Language, 39*, 85–101.
- Nation, K., & Snowling, M.J. (1999). Developmental differences in sensitivity to semantic relations among good and poor comprehenders: Evidence from semantic priming. *Cognition, 70*, B1–13.
- Nation, K., & Snowling, M.J. (2000). Factors influencing syntactic awareness in normal readers and poor comprehenders. *Applied Psycholinguistics, 21*, 229–241.
- Needleman, R.M. (1982). A linguistic analysis of hyperlexia. In E.J. Johnson & C.J. Thewd (Eds.), *Proceedings of the Second International Congress for the Study of Child Language* (pp. 473–482). Washington, DC: University Press of America.
- Niensted, S.M. (1968). Hyperlexia: An educational disease? *Exceptional Children, 35*, 162–163.
- O'Connor, N., & Hermelin, B. (1994). Two autistic savant readers. *Journal of Autism and Developmental Disorders, 24*, 501–515.
- Parker, S.W. (1919). Pseudo-talent for words. *Psychology Clinics, 11*, 1–7.
- Patti, P.J., & Lupinetti, L. (1993). Brief report: Implications of hyperlexia in an autistic savant. *Journal of Autism and Developmental Disorders, 23*, 397–405.
- Pennington, B.F., Gilger, J.W., Olson, R.K., & DeFries, J.C. (1992). The external validity of age- versus IQ-discrepancy definitions of reading disability: Lessons from a twin study. *Journal of Learning Disabilities, 25*, 562–573.
- Pennington, B.F., Johnson, C., & Welsh, M.C. (1987). Unexpected reading precocity in a normal preschooler: Implications for hyperlexia. *Brain and Language, 30*, 165–180.
- Phillips, A. (1930). Talented imbeciles. *Psychology Clinics, 18*, 246–265.
- Richman, L.C., & Kitchell, M.M. (1981). Hyperlexia as a variant of developmental language disorder. *Brain and Language, 12*, 203–212.
- Richman, L.C., & Wood, K.M. (2002). Learning disability subtypes: Classification of high functioning hyperlexia. *Brain and Language, 82*, 10–21.
- Rispens, J., & Van Berckelaer, I.A. (1991). Hyperlexia: Definition and criterion. In R.M. Joshi (Ed.), *Written language disorders* (pp. 143–163). The Netherlands: Kluwer Academic Publishers.
- Schlaggar, B.L., Brown, T.T., Lugar, H.M., Visscher, K.M., Miezin, F.M., & Petersen, S.E. (2002). Functional neuroanatomical differences between adults and school-age children in the processing of single words. *Science, 296*, 1476–1479.
- Seymour, P.H.K., & Evans, H.M. (1992). Beginning reading without semantics: A cognitive study of hyperlexia. *Cognitive Neuropsychology, 9*, 89–122.
- Shaywitz, B.A., Shaywitz, S.E., Pugh, K.R., & Skudlarski, P. (1996). Functional magnetic resonance imaging as a tool to understand reading and reading disability. In R.W. Thatcher (Ed.), *Developmental neuroimaging: Mapping the development of brain and behavior* (pp. 157–167). San Diego, CA: Academic Press.
- Siegel, L.S. (1984). A longitudinal study of a hyperlexic child: Hyperlexia as a language disorder. *Neuropsychologia, 22*, 577–585.
- Siegel, L.S. (1994). The modularity of reading and spelling: Evidence from hyperlexia. In G. Brown & N. Ellis (Eds.), *Handbook of spelling: Theory, process, and intervention*. United Kingdom: Wiley and Sons.
- Silberberg, N.E., & Silberberg, M.C. (1967). Hyperlexia: Specific word recognition skills in young children. *Exceptional Child, 34*, 41–42.
- Silberberg, N.E., & Silberberg, M.C. (1968–69). Case histories in hyperlexia. *Journal of School Psychology, 7*, 3–7.
- Silberberg, N.E., & Silberberg, M.C. (1971). Hyperlexia: The other end of the continuum. *Journal of Special Education, 3*, 233–242.
- Smith, I.S. (1988). Calculating prodigies. In L. Opler & D. Fein (Eds.), *Neuropsychology of talent* (pp. 70–102). New York: Guilford.
- Smith, I.S., & Bryson, S.E. (1988). Monozygotic twins concordant for autism and hyperlexia. *Developmental Medicine and Child Neurology, 30*, 527–535.
- Snowling, M. (2002). *Individual differences in children's reading disabilities: Sound and meaning in learning to read*. The Twenty-First Vernon-Wall Lecture. Leicester: British Psychological Society.
- Snowling, M., & Frith, U. (1986). Comprehension in hyperlexic readers. *Journal of Experimental Child Psychology, 42*, 392–415.
- Sparks, R.L. (1995). Phonemic awareness in hyperlexic children. *Reading and Writing: An Interdisciplinary Journal, 7*, 217–235.
- Sparks, R.L. (2001). Phonemic awareness and reading skills in hyperlexic children: A longitudinal study. *Reading and Writing: An Interdisciplinary Journal, 14*, 333–360.
- Sparks, R.L., & Artzer, M. (2000). Foreign language learning, hyperlexia, and early word recognition. *Annals of Dyslexia, 50*, 189–211.
- Task force on the nosology of disorders of higher cerebral functions in children. Proposed nosology of disorders of higher cerebral functions in children.* (1981). Child Neurology Society.
- Temple, C.M. (1990). Auditory and reading comprehension in hyperlexia: Semantic and syntactic skills. *Reading and Writing: An Interdisciplinary Journal, 2*, 297–306.
- Temple, C.M., & Carney, R. (1996). Reading skills in children with Turner's syndrome: An analysis of hyperlexia. *Cortex, 32*, 335–345.
- Tirosh, E., & Canby, J. (1993). Autism with hyperlexia: A distinct syndrome? *American Journal of Mental Retardation, 98*, 84–92.
- Trueswell, J.C., Sekerina, I., Hill, N.M., & Logrip, M.L. (1999). The kindergarten-path effect: Studying on-line sentence processing in young children. *Cognition, 73*, 89–134.
- Van Daal, V.H.P., & Miles, T.R. (2001, March). *Another look at the British births cohort study: Another explanation?* Paper presented at Annual Meeting of the British Dyslexia Association, York, England.

- Welsh, M.C., Pennington, B.F., & Rogers, S. (1987). Word recognition and comprehension skills in hyperlexic children. *Brain and Language*, *32*, 76–96.
- Whitehouse, D., & Harris, J. (1984). Hyperlexia in autism. *Journal of Autism and Developmental Disorders*, *14*, 281–289.
- Worthy, J., & Invernizzi, M. (1995). Linking reading with meaning: A case study of a hyperlexic reader. *Journal of Reading Behavior*, *27*, 585–603.

Manuscript accepted 13 May 2003