ABSTRACT

Hyperlexia is characterized by spontaneous and early acquisition of reading skills, manifested before the age of five, without any formal education. Expressive and receptive language deficit, excellent memory, delayed language skills, echolalia, perseverations, and difficulty to understand verbal contexts, are common symptoms in individuals with hyperlexia and global developmental disorders, including Asperger’s syndrome. The aim of this study was to describe the reading skills of individuals with hyperlexia. The participants were six boys with a history of hyperlexia, perceived by relatives before 36 months of life, chronologically aged between four years and four months to five years and two months. The following evaluation procedures were applied: interview with the parents or responsible guardians, communicative behavior observation, Peabody Picture Vocabulary Test (PPVT), recognition of alphabet letters and numbers, School Performance Test, text reading, and reading comprehension. The participants showed different performances in the PPVT, and recognized letters, numbers and isolated words. There was difficulty in answering the writing subtest; the majority did not understand the text that they read and all of them demonstrated recognition of letters and numbers. Some participants were able to read words and texts. However, all participants presented alterations in other areas of language development, such as receptive vocabulary, communicative behavior and understanding of the material read, in addition to altered behaviors of social adaptation, both interactive and restrictive.

RESUMO

Hiperlexia caracteriza-se pela aquisição espontânea e precoce da habilidade de leitura, manifestada antes dos cinco anos, na ausência de instrução formal. Déficit da linguagem expressiva e receptiva, excelente memória, atraso nas habilidades linguísticas, ecolalia, perseverações e dificuldade para compreensão do contexto verbal são sintomas comuns em indivíduos hiperléxicos com transtorno global do desenvolvimento, incluindo a Síndrome de Asperger. O objetivo deste estudo foi descrever as habilidades de leitura de indivíduos que apresentam hiperlexia. Participaram seis meninos, com histórico de hiperlexia percebida pelos familiares antes dos 36 meses de vida, de idade cronológica variando de quatro anos e quatro meses a cinco anos e dois meses. Foram aplicados os seguintes procedimentos de avaliação: entrevista com os responsáveis, observação do comportamento comunicativo, Teste de Vocabulário por Imagens Peabody (TVIP), reconhecimento de letras do alfabeto e números, Teste de Desempenho Escolar, leitura de texto e compreensão de leitura. Os participantes apresentaram desempenhos diferentes no TVIP, demonstraram reconhecimento de letras e números e de palavras isoladas. Entretanto, foram verificadas diferenças no desempenho deles. Houve dificuldade em responder ao subteste de escrita; a maioria não compreendeu o texto lido e todos demonstraram reconhecer letras e números, sendo alguns deles com habilidade de leitura de palavras e texto. Porém, apresentaram alterações em outras áreas do desenvolvimento da linguagem, como vocabulário receptivo, comportamento comunicativo e compreensão do material lido, somados aos comportamentos alterados de adaptação social, interativos e restritivos.
INTRODUCTION

Hyperlexia is characterized by spontaneous and early acquisition of reading skills, manifested before the age of five, without any formal education\(^1\). It can be a result of obsessive behavior associated with excellent development of visual-perceptive skills in a context of altered language development, and it is not necessarily correlated to intellectual abilities\(^2\). Precocious reading skills may indeed suggest that a child has superior intellectual abilities\(^3\). However, according to the literature, a child will present advancements in the development of specific brain areas, but with alterations in the areas of language and learning\(^4\). The mechanisms subjacent to this process have not been entirely understood\(^5\). It is inferred that this lack of knowledge is related to the prevalence of the phenomenon; in other words, the literature\(^2\) shows that the accurate prevalence rate of hyperlexia has not been entirely discovered, varying according to specific criteria\(^6\). The less rigorous these criteria are in relation to the diagnosis of hyperlexia in autistic children, the higher the discrepancy of prevalence rates. In addition, the few existing studies have presented isolated clinical cases. Joshi et al.\(^7\) conducted a study based on the bibliography published from 1999 to 2009 and found only 22 works on this topic.

The literature indicates, moreover, that individuals with hyperlexia demonstrate intense fascination for letters and numbers, difficulty to interact socially, and significant difficulty to understand spoken language\(^8\). Expressive and receptive language deficit, excellent memory, delayed language skills, echolalia, persistent behavior, and difficulty to understand verbal context are common symptoms in individuals with hyperlexia and global developmental disorders, including Asperger’s syndrome\(^9\).

Supported by the scarcity of studies on reading skills in early ages, the aim of this study was to describe them in individuals with hyperlexia.

PRESENTATION OF THE CLINICAL CASES

This project was approved by the Research Ethics Committee of School of Dentistry of Bauru of the University of São Paulo, where the study was carried out (protocol number 008/2012), and we complied with the criteria listed in Resolution 196/96. The participants’ legal guardians signed the informed consent form.

The inclusion criteria for this study were: having a history of precocious reading (hyperlexia) and having undergone a hearing evaluation that presented results within normal standards.

The legal guardians filled out an interview protocol composed of the following items: personal data and information about communicative and hearing development, behavioral characteristics, and medical diagnosis.

Following the selection, based on the data presented during the interview and on information about precocious reading, the participants were assessed through the application of the procedures described below:

- a) Communicative behavior observation (CBO): the child was exposed to a ludic activity with miniature toys in a semi-guided situation with the purpose of observing communicative intention, interaction with the assessor, eye contact, comprehension of simple commands, and fluency of verbal expression (speech acquisition and speech syntactic organization).
- b) Peabody Picture Vocabulary Test (PPVT)\(^10\): it provides objective information about receptive-auditory vocabulary. We followed the rules proposed in the instruction manual of the instrument, and the score obtained was distributed into the following categories: lower low, higher low, lower average, average, higher average, lower high, high, and higher high.

For the assessment of reading and writing skills, we used the following procedures:

- a) Recognition of isolated letters of the Latin alphabet (26 letters) and of numbers from 1 to 10.
- b) School Performance Test (SPT)\(^11\): we applied reading and writing subtests and obtained the total score (sum of the raw scores in both subtests). In accordance with the SPT manual, the participants were positioned within one of three levels of academic performance, taking into consideration the first year of elementary school: below average, average, and above average.
- c) Text reading and reading comprehension: after reading a children’s text (The Ugly Duckling), the child was supposed to tell the interlocutor what he/she had read. After the free retelling of what he/she had understood of the text, the assessor asked open and simple questions about it and its main characters. For the evaluation of the participant’s answers, the following categories were used: did not comprehend the text (DNC), in case the child was unable of reproducing the text and its central idea or did not answer correctly; comprehended partially (CP), if the child was not able to re-enact the text but demonstrated comprehension of its central idea, answering the questions posed by the assessor; and comprehended (C), in case the child comprehended the text that was read and answered all the questions correctly.

Six boys participated in this study, with behaviors compatible with global developmental delay and history of hyperlexia, perceived by relatives before 36 months of age. The medical diagnoses were given by several professionals, neurologists, or child psychiatrists. The medical reports presented participants P1, P2, P3, and P5 with ICD (World Health Organization International classification of diseases) F84.5 (Asperger’s Syndrome), and P4 and P6 with ICD F84 (global developmental delay). None of the participants were in therapy prior to the study.

It is worth highlighting that we did not employ socioeconomic criteria in the selection. With regard to the schooling of the mothers, P4’s and P6’s mothers finished elementary school; the mothers of P1, P3, and P5 finished high school, and P2’s mother had an undergraduate degree.
Table 1 displays the observed participants’ characteristics in relation to their age at the time of the evaluation, the age when the family noticed the child’s reading skills (hyperlexia), limited interests, and poor adaptive behavior. With regard to schooling, P1, P3, P4 and P5 attended public school and were enrolled between the second and third year of life, and P2 and P6 did not attend school because of adaptation difficulties.

During the interview, the following characteristics were common in the participating family members’ reports: social isolation, poor adaptive behaviors, difficulty to change routines, difficulty in school integration, impulsiveness, interest in activities that involve reading, and limited interests.

During the CBO, we verified that P5 and P6 presented communicative intention and interaction with the evaluator, and P1, P2, P3 and P4 showed communicative intention and interaction only in situations of their own interest. P1, P2 and P4 did not make eye contact, while P3, P5 and P6 indicated limited eye contact. All the participants demonstrated comprehension of simple commands and formed words or sentences, especially in relation to topics of their own interest. Through observation of communicative behavior, the participants presented syntactically correct speech and fluency in verbal expression, without the presence of phonological processes unexpected in this age range.

Table 2 shows the results of the PPVT, tests of recognition of letters and numbers, SPT reading and writing subtests, and reading comprehension.

<table>
<thead>
<tr>
<th>Participants</th>
<th>Age</th>
<th>Perception of hyperlexia</th>
<th>Limited interests and behaviors</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>4 years and 4 months</td>
<td>30 months</td>
<td>Interest in card games of questions and answers, flapping and leg shaking, use of stereotyped expressions, such as: “Wait for your turn,” “please,” “particular,” and “naturally.”</td>
</tr>
<tr>
<td>P2</td>
<td>4 years and 6 months</td>
<td>36 months</td>
<td>Interest in dinosaurs, tapping fingers on ears and carrying miniatures of dinosaurs or magazines around interest in newscast television shows.</td>
</tr>
<tr>
<td>P3</td>
<td>5 years</td>
<td>24 months</td>
<td>Mood oscillation, repetition of senseless words, interest in puzzles and maps.</td>
</tr>
<tr>
<td>P4</td>
<td>4 years and 6 months</td>
<td>Before 36 months</td>
<td>Organizes everything in rows, walks to and fro, uses jargons.</td>
</tr>
<tr>
<td>P5</td>
<td>5 years and 2 months</td>
<td>Before 36 months</td>
<td>Interest in material written with the use of computers and fight videogames, bites nails and cuticles, impulsive and explosive, has severe food restrictions.</td>
</tr>
<tr>
<td>P6</td>
<td>4 years and 9 months</td>
<td>30 months</td>
<td>Interest in phone books and puzzles, unusual fears, habit of placing hands under armpits.</td>
</tr>
</tbody>
</table>

Table 2. Results of the PPVT, recognition of graphemes and numbers, SPT (writing and reading), and comprehension of the material read

<table>
<thead>
<tr>
<th>Procedures</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
<th>P5</th>
<th>P6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grapheme recognition (%)</td>
<td>Lower average</td>
<td>Lower low</td>
<td>Lower low</td>
<td>Lower low</td>
<td>Higher</td>
<td>Higher</td>
</tr>
<tr>
<td>Number recognition (%)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>SPT: reading</td>
<td>Higher</td>
<td>Average</td>
<td>Average</td>
<td>Lower</td>
<td>Higher</td>
<td>Higher</td>
</tr>
<tr>
<td>SPT: writing</td>
<td>*</td>
<td>Lower</td>
<td>*</td>
<td>Lower</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Comprehension of the material read</td>
<td>DNC</td>
<td>DNC</td>
<td>DNC</td>
<td>DNC</td>
<td>C</td>
<td>CP</td>
</tr>
</tbody>
</table>

Legends: C = comprehended; CP = comprehended partially; DNC = did not comprehend; PPVT = Peabody Picture Vocabulary Test; SPT = School Performance Test; * = refused to write; * = motor difficulty to perform the writing task.

DISCUSSION

During the CBO, we verified that the majority of the participants presented limited interaction with the evaluator, always related to situations that met their own interest. All participants demonstrated comprehension of simple commands, and the syntactic organization and speech development were adequate to their chronological age.

The analysis of the receptive language of the six participants assessed through receptive-auditory vocabulary resulted in different scores, considering the classification standards proposed by the PPVT. Lexical development reflects a child’s ability to understand and elaborate the enunciations that will be present in his/her communication. This ability facilitates and promotes information exchange between the child and his/her interlocutors, allowing and permeating the communicative process.

Through the use of the same instrument (PPVT), a study(12) with individuals with Asperger’s syndrome demonstrated their difficulty with receptive language. Indeed, the literature(13) indicates that language development in individuals with Asperger’s syndrome is founded on isolated and limited interests, which impairs the process of language acquisition. Another study(5) reports that problems with receptive language are more common than difficulties with expressive language and that the nature of this compromise remains insufficiently described. The authors inform that the problems with language reception can affect the social behavior of children with Asperger’s syndrome.
and Pervasive Developmental Disorders, thus contributing to
deficits in communication, especially influencing the use of
language. With regard to the scores obtained in the PPVT,
the participants of the present study proved to be a heterogeneous
group in relation to this skill. This finding is verified through
the performance of P5 and P6, who presented higher and higher
average PPVT classifications respectively, while P2, P3 and P4
registered lower low, and P1 lower average.

Even when imbued with a good receptive-auditory
vocabulary, hyperlexics might not comprehend the mate-
rial read. For this reason, the role of semantic knowledge
in reading has been the object of considerable debates,
particularly in relation to the degree in which semantics
is necessary for the successful reading of regular and es-
pecially, unusual words(7).

On the other hand, alterations in communicative skills, such
as difficulty to understand a verbal context, to initiate and main-
tain eye contact and dialogues, and the utilization of unusual
words, besides the lack of interest in activities not related to
reading, were observed in a more consistent and homogeneous
manner in the participants of this study, which is in accordance
with the findings reported in the literature(2,5,12,13).

Concerning the recognition of letters and numbers, we
observed that all participants had this ability, and the same was
verified in the SPT reading activities. In other words, all par-
ticipants were able to read isolated words, but with differences
in performance (Table 2), which varied from below average to
average and above average, considering the scores of the first
year of elementary school. Child P4, for instance, was not able
to read all the words on the reading test, but was able to do so
with high frequency words, such as “duck”.

According to the connectionist model, the decoding of a
word can occur by different routes — phonological, ortho-
graphical, and semantic — depending on the child’s level of
reading(9). Another model(7) suggests that the lexical route
favors the access to stored representations of orthographical
forms of known words, which, in turn, are linked to their
phonological form, thus prompting the correct pronunciation
of the word in question.

There seem to be two sub-routes of the lexical route in this
model. In the first, the spoken representations are accessed
directly from their orthographical representations without se-
matic mediation, and the second route involves the conversion
of orthography to phonology through semantics. According to
Newman et al.(3), the dissociation between the ability to read
and the semantic knowledge seems evident in some hyperlex-
cics, given that the acquisition of the ability to read regular
and especially unusual words, can occur in a context of impaired
comprehension. Nevertheless, as time goes by, some hyperlex-
cics are able to comprehend contents they read, depending on
the development of maturing processes. This heterogeneity
offers the ideal opportunity to test hypotheses about this barely
known phenomenon(7).

Indeed, on the course of the application of the instruments,
we verified that the participants demonstrated different per-
formances in verbal behavior as well as reading, in addition
to altered behaviors of social adaptation, both interactive and
restrictive. Despite the occurrence of atypical and restrictive
behaviors, P1, P5 and P6 were less reluctant to activities that
were not of their interest. This behavior was particularly dif-
ficult for P2, P3 and P4.

A study by Nation et al.(1) about the reading skills of chil-
dren with disorders of the autistic spectrum, demonstrated
that the nature of the reading abilities in these individuals is
heterogeneous.

The writing subtest was also difficult to apply because of the
lack of interest in this activity. Participants P3 and P4 refused
to take part, and P1 and P5 presented motor difficulty in the
subtest as well as in the codifying of written words. P2 and P6
performed the task with difficulty to write the words dictated
due to motor problems.

In the reading comprehension test, participants P1, P2,
P3 and P4 did not demonstrate comprehension. According
to the literature, this behavior is expected in hyperlexics
and is related to an obsessive conduct along with an ex-
cellent development of visual-perceptive abilities, visual
association and memory, in a context of altered language
development(2-4,8). This might indicate(3,8) that even with diff-
culties in the use of linguistic abilities, these children take
the phonological route in order to decode graphic symbols.
However, they do not comprehend the material read, which
confirms the literary affirmation that hyperlexia seems to
be a mechanical activity of graphemephoneme transcod-
ing(5). Another hypothesis for this phenomenon is that the
child can develop an orthographical memory conducive to
an advantageous analytical visual configuration, which, in
turn, favors the act of reading(8).

According to the literature(9), children with hyperlexia
depend on phonological and orthographical skills in order to
read, but the strong and weak points of these skills remain
unclear. Newman et al.(3) inform that for these individuals, read-
ing cannot be explained based exclusively on visual memory;
instead, it involves, at least to a certain degree, mapping and
decoding, which suggests that these individuals rely on phono-
logical processing to identify regular words. Another study(9)
presented the concept of parallel mapping between graphic
and phonological codes, stating that this notion draws on the
evidence that when the order of the words in a text is changed,
typical children tend to demonstrate decreased reading speed
in comparison to hyperlexics.

Indeed, intensive practice with printed words leads to a
precocious ability to read isolated words. However, evidence
suggests that although they start reading earlier, individuals
in this sphere might not develop the same processes of typi-
cal readers, i.e. the phonological and lexical mapping that
aid in the recognition of simple words. Thus, the reading
of single words is disconnected from the comprehension of
the entirety of a text(8), which then prevents the compre-
hension of letters and sentences. Participants P2, P3 and
P4, for instance, were not able to read the text, but they
could read words and excerpts. It is worth highlighting that
those who presented better results in receptive vocabulary

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(P5 and P6) also had a better comprehension performance (Table 2). A limitation of this study refers to the lack of previous knowledge about the degree of familiarity that the participants had with the story chosen for the evaluation of reading comprehension.

Comprehension is a complex process that involves a wide range of neuropsychological processes related to cognitive and psycholinguistic abilities, information processing, stimuli integration, and monitoring of affective and behavioral states.

A study by Turkeltaub et al. reported that the neural foundations responsible for early reading remain unexplored. The authors informed that the elucidation of the neural foundations of reading in hyperlexics could clarify the neurobiology of the reading process in a context of poor language and communication skills, as well as favor the identification of alternative routes for reading that would benefit children with difficulties in linguistic and communicative development. Despite the disagreement about hyperlexia being a condition specific to individuals who present autistic characteristics, Newman et al. consider hyperlexia as a phenomenon specific to this group.

From a neuropsychological perspective, the abilities demonstrated by hyperlexics refer to excellent perception, differentiation, association, and visual memory, along with linguistic abilities of associating language sounds with written material, which is detrimental to the ability of processing, organizing, integrating, and comprehending oral and written language. Mottron et al. suggest that hyperlexia represents a canonical example of the perceptual use of linguistic units, thus suggesting that the comprehension of the models of reading development, in these cases, must be understood not only in light of subjacent mechanical processes but also in the context of oral language and reasoning abilities, which is also affirmed in the literature on the topic.

Although they demonstrated competence to recognize and read written words without formal education, as it is expected in the case of individuals with Asperger’s syndrome, the participants of this study presented alterations in the performance of activities of communication and social adaptation that interfere with the quality of interpersonal interactions, oral and reading comprehension, and learning.

It is known that hyperlexic children have heterogeneous diagnoses with associated co-morbidities. In light of this, a more attentive look at individual variability, combined with longitudinal follow-ups can be helpful in the comprehension of the development of reading skills. The reduced number of participants and the different methodologies employed in studies on the topic limit the possibility of extrapolating the data displayed in the evaluations of the general population of hyperlexics. Although several models or hypotheses to explain the reading skills of hyperlexics have been pointed out, the mechanisms that ignite this process are still poorly comprehended.

**FINAL COMMENTS**

The participants with hyperlexia in this study demonstrated recognition of letters and numbers. Some of them were able to read words and text, but with alterations in other areas of language development, such as receptive vocabulary, communicative behavior, and comprehension of the material read, in addition to altered behaviors of social adaptation, both interactive and restrictive.

*ATF was responsible for data collection and tabulation; LMP collaborated in data collection and tabulation; MMG supervised data collection and collaborated in data analysis; DMCL was responsible for the project and the study outline, and overall supervision of the manuscript stages.

**REFERENCES**