



Original article

Is hiragana decoding impaired in children with periventricular leukomalacia?

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Abstract

Background: There are few studies on hiragana reading skill and phonological awareness in Japanese schoolchildren with periventricular leukomalacia (PVL).

Methods: Three seven-year-old children with PVL who had no intellectual disabilities or dysarthria were recruited. Their perinatal information, brain magnetic resonance image (MRI) at term equivalent age, accompanying neurodevelopmental disorders, ophthalmologic features, Kaufman Assessment Battery for Children (K-ABC), a hiragana reading test (four tasks), and a phonological awareness task (mora reversal tasks) were analyzed.

Results: Patient (Pt) 1 and pt2 were male. Pt2 and pt3 were siblings of triplets. Their gestational age was 28 or 32 weeks, and their birth weights were 1196, 1554, and 1848 g, respectively. Their brain MRI revealed cystic or non-cystic periventricular white matter injury involving the deep white matter at the trigone of both lateral ventricles. Pt1 had attention-deficit/hyperactivity disorder and pt3 had pervasive developmental disorder not otherwise specified. All patients had strabismus with spared best-corrected visual acuity. Scores of Reading/Decoding in K-ABC ranged from 89 to 99. As for the single mora reading task or the non-word reading task in the kana reading test, Z scores of their reading time ranged from 2.3 to 5.9 compared to control children. Pt1 and pt3 made significant errors in the mora reversal task of three-mora words, whereas all patients could answer all words correctly in the mora reversal task of two-mora words.

Conclusion: All children showed significantly prolonged reading time despite their adequate letter recognition. Two patients showed delayed phonological awareness. It was suggested that hiragana decoding impairment due to subcortical and/or cortical injury related to PVL affected their reading ability.

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Keywords: Cerebral palsy; Diplegia; Dyslexia; Cerebral visual impairment; Phonological awareness; Reading test

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1. Introduction

Patients with periventricular leukomalacia (PVL) were reported to be at risk of lower academic achievement at school age, including lower reading ability [1]. In extremely low birthweight infants with periventricular brain injury, reading performance at age 11 was associated with auditory working memory and phonological processing skills such as the ability to decode English words or non-words after manipulating an alphabet [2].

However, there are few studies on the reading ability of Japanese children with PVL, especially among patients with PVL without intellectual disability. Previously, we reported that reading speed and accuracy were impaired in a 13-year-old boy with PVL who had mild intellectual disability [3]. Japanese kana characters (hiragana and katakana) are phonograms and have extremely clear letter-to sound correspondence [4]. Previous studies revealed that Italian dyslexics, using simple letter-to sound correspondence, made fewer errors but with equally impaired reading speed compared to English or French dyslexics [5], suggesting that reading speed is more sensitive for screening reading disability than reading errors. Therefore, reading speed should be studied when screening for hiragana reading disability in Japanese children.

Decoding is a critical skill in reading. Decoding refers to a skill determining the pronunciation of a word by analyzing the vowel and consonant combinations within the word [6]. One hiragana letter represents a mora, which is a minimal phonological unit of Japanese that consists of one vowel and/or consonant. Some of the single hiragana characters represent a word with one or more different meanings. For example, a hiragana character “ki” has word meanings such as “yellow” or “tree” in Japanese. For these reasons, we applied the term “decoding” to the letter-to sound relationship in hiragana, which has often been used in previous studies [7–9].

Phonological awareness is another important factor in achieving reading. Phonological awareness is defined as awareness of the sound structure of the language that enables one to recognize, identify, and manipulate syllables and phonemes within the spoken language [6,10]. Development of phonological awareness in early childhood is critical when learning how to decode a written language, and also reading itself is critical for further development of phonological awareness [10]. A task of reversing the order of sound in words is useful for measuring the subject’s phonological awareness [10,11].

In the present study, we studied three seven-year-old children with PVL with no intellectual disabilities and analyzed their kana reading ability including their reading speed and their phonological awareness, as well as their other cognitive abilities.

2. Patients and Methods

The inclusion criteria for this study were children with PVL who were first grade students with no intellectual disabilities, used Japanese as their mother language, and had no dysarthria in their spoken language in daily communication. From April 2011 to March 2017, three patients at Aichi Prefectural Colony Central Hospital who met these criteria agreed to join this study. Patients 2 and 3 were male and female siblings of triplets. The other sibling had no academic difficulties and was not referred to the hospital. Mothers of the patients completed high school or higher education. None of the patients showed major language delay or required speech therapy in infancy. All three were right-handed and went to local elementary schools without special educational supports, and all three attended school regularly with no school refusals. Patients 1 and 2 were hospitalized for three months for Achilles tendon-lengthening surgery when they were in first grade. During the hospital stay, they were temporarily transferred to an elementary school inside Aichi Prefectural Colony Central Hospital and received appropriate education. None of the patients were on daily oral medication before or during their cognitive and reading tests. Reading complaints of the patients were as follow. Patient 1 was recognized to make many mistakes when reading an unfamiliar text aloud. Patient 2 had a problem following the line when reading aloud; he sometimes jumped to the wrong line or had difficulty moving on to the next line appropriately after finishing the line. In patient 3, no reading problems were recognized by the subject herself or her mother.

The following patient characteristics were analyzed in the present study: clinical characteristics and presence of retinopathy of prematurity (ROP) in the neonatal period, and types of cerebral palsy, general motor function by Gross Motor Function Classification Systems (GMFCS) [12], presence of pervasive developmental disorder (PDD) or autism spectrum disorder (ASD), presence of attention-deficit/hyperactivity disorder (AD/HD), ophthalmological features including best-corrected visual acuity, features of fundus, presence of strabismus, and Titmus Stereo Test outcomes at age seven. Also, brain MRI at term equivalent age and at age seven were analyzed. Patient 1 was assessed for ASD or AD/HD using the diagnostic criteria of Diagnostic and Statistical Manual of Mental Disorders (DSM), Fifth Edition by a pediatric neurologist. Patient 2 and 3 were assessed for PDD or AD/HD using diagnostic criteria of DSM, Fourth Edition, Text Revision by a pediatric neurologist or a pediatric psychiatrist.

Three psychological tests were performed to assess their cognitive abilities: Wechsler Intelligence Scale for Children (WISC) –III or –IV, Kaufman Assessment

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