

## Understanding and Overcoming Dyslexia: Insights from Alphasyllabary Writing System and Neuroimaging

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### **Abstract**

Dyslexia or reading and spelling difficulty, is a learning disability that has the highest incidence among all other learning disabilities. The International Dyslexia Association defines dyslexia as a specific learning disability that is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities. These difficulties result from a deficit in the phonological component of language despite average to normal intelligence and effective classroom instruction. This definition however may not be entirely applicable to the Indian context as various factors such as multilingualism, low literacy rate, lack of awareness, and socio-economic factors can affect its diagnosis. In the Indian scenario, studies have been conducted to prove the relation between the complex orthographic system and its impact on reading development in children. This study in the similar vein, attempts to understand the manifestation of dyslexia in the context of Assamese which employs a complex alphasyllabary script. It talks about its inconsistent mapping between phonemes and graphemes and attempts to build a connection between reading difficulties and opaque language structure with an understanding on the importance of early intervention and neuroimaging research.

**Keywords:** Dyslexia, phonological awareness, orthographic awareness, dyslexia assessment battery, Assamese, neuroimaging, Akshara, early intervention

## Introduction

There has been a growing interest in the research of learning disabilities, especially in the context of India. This is because, unlike in other developed countries, identifying dyslexia in Indian classrooms can be challenging. There are various external factors that can affect the diagnosis of dyslexia in India. Most pertinent being the lack of awareness, followed by the socio-economic disparity in classrooms, and pedagogical factors such as poor quality of teaching. Shaywitz (1998) has reported that one of the most common language learning impairments is dyslexia affecting the ability to read. It has a worldwide incidence of 5-20 per cent (Shaywitz & Shaywitz, 2008) and 10-15 per cent in India (Chatterjee, 2016). Dyslexia falls under specific learning impairment as it is characterized by an unexpected difficulty in reading in children or adults who possess the intelligence, motivation and schooling considered necessary for accurate and fluent reading (Shaywitz, 1998). There are many theories that discuss the manifestation of dyslexia in children, the most common being phonological deficit theory or the inability to break down the phonological units from a given word.

According to Frith (1985), reading skills acquisition occurs in three stages. First, the logographic stage, where the children can recognize some words, but they are not aware of the sound and letter correspondence. The second stage is the alphabetic stage, which has two prerequisites: phonemic awareness (of various speech sounds, such as rhyme, syllable, and individual phonemes 'tap' - 't', 'a', 'p'); and understanding alphabetic principle (relation between the spoken language to the written language, 'visual stimuli', 'auditory stimuli'). The second prerequisite is phonological route development, which takes place in three steps: segmentation (separating the sounds in a word); decoding (conversion of a letter to sound); and fusion (pronouncing the word by fusing phonemes corresponding to the graphemes). The final stage is the orthographic stage, in which there is a holistic approach (rapid whole word recognition), achieves reading fluency, and understands spelling patterns. In Assamese medium schools, the instruction begins from the alphabetic stage where the teacher asks the children to repeat the letters commonly known as barnamala, starting from vowels such as  $\square$  /  $\square$  / and when the vowels are learnt well, they begin learning the consonants such as  $\square$  / k  $\square$  / (there is a presence of the inherent vowel in most consonants of Assamese) after this stage, children start learning

the words associated with the letters, such as □ /k □/for □□□ “ear”, at this stage they also learn to segment the letters into corresponding sounds. However, it may be observed that while learning words in the pre-primary level, they seem to only associate the letters in the word with the letters learnt in isolation and store in their visual memory, this is because they are not able to differentiate between inherent vowel □ /k □ /and the secondary vowel diacritic □□ /ka/. Usually in grades 2-3 the child learns to read the whole word presented to them; this can be done only when they are able to achieve reading fluency from whole word recognition. Conversely, a poor reader will have difficulty decoding the word to sound segments.

Dyslexia is an issue of phonemic awareness resulting in the difficulty in graphemes to phonemes conversion. Therefore, languages with transparent writing systems are the ones whose speakers have relatively low rates of dyslexia because it is easier to convert graphemes to phonemes when there is almost one-to-one correspondence (Dulude, 2012). There are many languages that follow one-to-one grapheme-phoneme mapping, such as Spanish and German. On the other hand, there are grapheme-phoneme inconsistencies observed in languages such as English and French. It is evident that Indian languages such as Assamese largely demonstrate non-transparent orthographies. For instance, the word /k□m□l□/“orange” has 6 phonemes, with inherent vowel sound /□/ but when written in Assamese □□□□ has 3 graphemes and one secondary diacritic or a vowel ligature (bound symbol). Also, children learning Assamese are taught to read two different letters for the same sound, for instance for the alveolar nasal sound /n/ there are two letters, □ called murdhoinnya nɔ and □ called dontia nɔ. Likewise, three Assamese alphabets □, □, □ represent the voiceless velar fricative /x/. These sounds in consonant clusters, also called juktakkhor in Assamese change into /s/. A typically developing child may not face difficulty in reading as their cognitive systems are well equipped to tackle such inconsistencies, but a dyslexic child can suffer to a great extent when they start acquiring complex and inconsistent language systems. Opaque and transparent orthographies help us to understand the ease at which children learn to read. Learning opaque orthographies can be a complex procedure as it means that the graphemes does not map into the phonemes (Rack et al., 1994). There is an association that can also be observed with increasing Akshara knowledge in children and reading

and phonological development (Nag, 2007). Children who acquire the knowledge of Akshara in Grades 1-2 are regarded as better readers in higher grades than those who could not acquire the Akshara knowledge when they were in Grades 1-2. It has been reported that primary school children who are poor readers find it difficult to identify aksharas with vowel makers such as क /ka/ and the aksharas with consonant clusters क्त /nt/ such as क्त /nt/ "end". A qualitative analysis of errors during reading showed difficulty with voiced-unvoiced sounds such as खित /xit/ "winter" and खित /zit/ "victory" and aspirated-unaspirated sounds such as ब्र /br/ "very" and भर /bh/ "fill". These findings tell us that there is a significant correlation between children's level of Akshara knowledge and their reading accuracy scores across all Grades from 1 to 4 (Nag & Sircar, 2008).

The diagnosis of dyslexia is challenging because of two reasons: first because of the lack of awareness on the part of parents and teachers, and second because it is not diagnosed till the child reaches primary school. While the cognitive profiles of poor readers showed difficulties in multiple domains including oral language, phonological processing, speed of processing and visual processing, akshara knowledge emerged as the common area of deficit (Torppa et al., 2006). Another factor to consider while assessing dyslexia is that the majority of school children are biliterate, i.e they learn two languages simultaneously. The Indian education policy mandates teaching Indian languages in addition to English (Viswanatham, 2001). It is reported that learning to read many languages simultaneously multiplies the challenges of literacy acquisition in children who struggle with reading and spelling, they can have trouble in the acquisition of a larger set of sound-to-symbol correspondences, mastery of different orthographic rules, even learning distinct principles for mapping sound to meaning (Rao et al., 2021). Most Indian languages employ orthographies based on akshara as the basic visual unit, and the writing systems of these languages are variously termed "akshara orthography", "alphasyllabary", and "abugida" (Share & Daniels, 2016). Alphabetic languages represent sounds at the level of phonemes. Thus, the syllable /nu/ is represented by the two letter symbols of English, 'n' and 'u'. Unlike alphabetic languages, Akshara writing systems represent sounds at the level of both the syllable and the phoneme simultaneously and are thus called alphasyllabaries or abugidas (Daniels, 1996). Assamese employs alphasyllabary with alphabet and syllable occurring

simultaneously such as □□, □□, □□ representing /ka//ke//ku/. Bhide et al. (2014) state that in alphasyllabaries, diacritics are used to mark all vowels following consonants, except for the schwa vowel, which is inherent in every consonant, and is marked or unmarked depending on its position within a word. Akshara languages indicate that there is an additional challenge to learning to become literate - learning to segment written symbols into their component parts (Nag, 2011).

Phonological awareness is one of the most important predictors of reading in normally developing children (Rack et al., 1994; Wagner et al., 1987). There have been a few tests to assess phonological awareness in children. These tests are programmed to identify the phonological deficits a child may face in a language they are learning, that could later result in reading difficulties. Two most popular tests are the Phonological Assessment Battery and DALI-DAB—the Dyslexia Assessment Battery (DAB) of the Dyslexia Assessment for Languages of India (DALI). The PhAB2 is targeted for children aged 6 to 14 and identifies their phonological difficulties that result in delayed or poor reading. There are six standardized tests including the Alliteration Test—assesses a child’s ability to isolate the initial sounds in single syllable words. The Naming Speed Tests—assesses a child’s speed of phonological production. It also includes the Picture Naming Test and the Digit Naming Test. The Rhyme Test—assesses a child’s ability to identify the rhyme in single syllable words. The Spoonerisms Test—assesses whether a child can segment single syllable words and then synthesize the segments to provide new words or word combinations. The Fluency Tests—assesses a child’s retrieval of phonological information from long-term memory. The Non-Word Reading Test—assesses a child’s ability to decode letter strings. This battery was developed by researchers at University College London and has been used extensively by researchers to identify phonological difficulties in children. Considering the diversity of factors involved in identifying children with dyslexia in Indian classrooms, a specific type of assessment tool has been designed. This assessment battery called Dyslexia Assessment of Languages in India (DALI) is the first screening and assessment tool for dyslexia in regional Indian languages. It contains screening tools for school teachers and psychologists in four Indian Languages. DALI was developed at the National Brain Research Centre under the leadership of Prof. Nandini Chatterjee Singh and her team under the aegis of a project supported by the Department of Science

and Technology, Government of India. This test is a diagnostic battery to identify children with dyslexia and is meant to assess the phonological difficulties faced by a child while learning a language at school. It comprises two levels, one for primary school children and the other for middle school and above. DALI evaluates reading skills, including letter recognition, word and non-word reading, letter and word spelling/dictation, and reading comprehension, but also incorporates tests of mediator skills in the domains of phonological awareness, processing automaticity and executive function, and oral language ability. This assessment battery will be particularly useful in assessing reading disorders in Akshara-based languages such as Assamese.

Dyslexia is a disorder that has a neurobiological origin. Neuroimaging allows researchers to understand how readers with dyslexia use decoding and sight recognition to read and how the reading behaviour of people with dyslexia differs from people with typical reading development. Kearns et al. (2013) report that individuals with good and poor reading differ in their patterns of activation, in terms of the degree to which they activate parts of the brain associated with reading, such as recognizing familiar print (the occipitotemporal region), linking letters and sounds (the temporoparietal area), and processing phonemes (the inferior frontal gyrus). Importantly, readers with dyslexia do not only show less activation overall; they show a different pattern of activation. In India, Kumar et al. (2010) have researched neuroimaging in Akshara orthographies. Their studies demonstrate that the complex visuospatial nature of Akshara writing systems require a bilateral neural reading network, different from alphabetic writing systems, which predominantly report left lateralized networks for reading. Electroencephalography (EEG) is used to identify unique brain activation patterns in individuals with dyslexia. EEG may help psychologists to complement current dyslexia assessing techniques as it could add a neurological point of view. EEG research has revealed that dyslexics' brain is normal and healthy; it takes a longer time to make connections compared to normal people (Mohamad et al., 2013). A study (Arns et al., 2007) revealed that the dyslexic group had increased slow theta and delta activity in the frontal and right temporal areas of the brain. Although dyslexia has a neurobiological origin, the conventional dyslexia detection techniques used are often based on behavioural aspects such as reading, writing, intelligence quotient (IQ) and memory abilities (Perera et al., 2018).

Deficits in the wide network of brain areas responsible for phonological skills cause reading difficulties (Norton et al., 2015). It has also been reported that dyslexia is linked to genes. Reading is a mechanism that consists of phonological decoding, morphological and syntactic processing and it indicates the involvement of genes in this complex language learning process (Sriganesh et al., 2018). Even though dyslexia has neurological, biological, and social underpinnings (Rahul & Ponniah, 2021), it is imperative to state that timely intervention can manage the problem significantly (Snowling, 2013). In developing nations, identification alone can be challenging due to various factors, most common being lack of awareness. School is the place where dyslexia is usually identified because a child begins formal education and learns to link sounds with letters of the language with the help of teachers. Therefore, educators should be extra vigilant about the early signs of dyslexia during the pre-school stage. Elbro and Petersen (2004) found that the dyslexic children who were intervened in their kindergarten outperformed the children who were not intervened in the phonological awareness and letter knowledge tasks. There is a wealth of research on the intervention methods in the education context. However, the outcome of these interventions depends on various factors such as level of intelligence, complexity of orthography, socio-economic status, etc. Children with dyslexia also benefit from technology-assisted interventions (Kalyvioti & Mikropoulos, 2014; Madeira et al., 2015; Rooms, 2000).

Dyslexia being a learning impairment, can affect the life of both the child and parents. In Western countries, however, corrective measures are effective due to early intervention. Taking the example of English in the West, although it employs deep orthography, it is still easy to learn because of the alphabetic system of writing and its contained orthography with just 26 letters, without any visually complex conjunct consonants unlike many Indian languages. Thus, more research needs to be conducted on how Indian languages with the akshara system can affect reading ability in children. Brain imaging research should also be emphasized as it can indicate any atypical markers in the language processing areas of the brain especially while processing deep complex orthographies.

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