

Syllabic Complexity, Metalinguistic Deficits and Reading in Developmental Dyslexia

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ABSTRACT

A metalinguistic deficit in the awareness of phonological aspects of spoken language has long been assumed to be the single most important cause of reading failure among developmental dyslexics. Majority of this proposal's empirical support has come from examination of reading problems in irregular language like English and its relation to the alphabetic principle of reading acquisition. Results discussed in this paper tests this hypothesis among a group of Oriya speaking developmental dyslexics on different metaphonological tasks and a set of reading tasks varying in syllabic complexity. Increase in the syllabic length of words also increases the phonological complexity of words thus eliciting a hierarchical of word reading in dyslexics. Compared to real words such deficits could be even more serious for reading of non-words in dyslexics. The results demonstrate how length of words could be a serious problem for developmental dyslexics for efficient decoding along with their metaphonological deficits. Results are interpreted towards a possible 'syllabic' awareness preexisting in Oriya speaking developmental dyslexics compared to 'phonemic' awareness within the general theoretical framework which considers 'syllables' as fundamental units of speech planning, production and reading.

INTRODUCTION

Developmental dyslexia: Biological and linguistic deficits

The study of developmental dyslexia is significant for its linguistic implications on the one hand and its relation to

linguistic and cognitive constraints involved in the reading processes on the other. Dyslexia is typically defined as a reading and spelling problem that cannot be accounted for by sensory or neurological damage, lack of educational opportunity or low intelligence (Stanovich 1986; Vellutino 1979). However the role of intelligence per se causing developmental dyslexia has been challenged (Siegel 1989). Although the use of the word “dyslexia” remains controversial there is considerable evidence that many reading problems in children are caused by language deficiency within the phonological domain. This deficit in mapping the phonological knowledge of spoken language in the developmental years in acquiring skills in grapheme to phoneme conversion has been the central hallmark of developmental dyslexia. There is no unanimous view on what sets of deficits truly constitute a conceptual and empirical definition of dyslexia that may be valid across languages, orthographic designs, and reading strategies and how specifically it is different from reading deficits seen in other developmental language disorders in the early years of literacy development (Bishop et al. 2004). It has been suggested that, amid all the available results, phonological deficiencies associated with phonological coding deficits are the probable causes of developmental dyslexia rather than visual, semantic, or syntactic deficits. Although reading difficulties in some children may be associated with general language deficits. Hypothesized deficits in general learning abilities may include attention, association learning, cross-modal transfer (Vellutino et al. 2004).

The basic postulate of current research on developmental dyslexia considers it fundamentally linked to constitutional characteristics of the brain (Habib 2000). The concept of a specific reading disorder without a focal organic basis to it has also been often controversial as more and more studies have reported some or other form of developmental anatomical deficits in the dyslexic’s brains (Galaburda & Kemper 1979). There has been empirical evidence of subtle differences in white matter structures in the left temporo-parietal region between dyslexic’s and normal readers suggesting a neurodevelopmental perspective to the problem of literacy acquisition (Niogi &

McCandliss 2006). Recent research in the domain of neuroscience of temporal processing deficits has related reading deficits to speech perception abnormalities (Mishra 2006). Investigations in the volumetric measurement of specific brain areas, more specifically the plenum temporal is shown to have more symmetry in both the hemispheres in dyslexics than they are in normal readers suggesting early deficit for temporal coding of speech which is so essential for development of metaphonological skills. However, how such symmetry of language specific anatomical areas develops during earliest periods of brain maturation and how this leads to dyslexia or deficits in spoken language awareness is not yet known. Hence in the light of stronger evidence emerging on the biological basis of dyslexia, dyslexic's linguistic deficits deserved to be seen as broad neurocognitive abnormalities seriously affecting the progress towards literacy. Apart from the biological view of dyslexia, the fact that worlds languages display remarkable variation in the design of their orthographies and the way they are used in grapheme to phoneme conversion has added fuel to the debate of variability among dyslexic's deficit patterns among different cultures and languages in spite of a possible common neuro-anatomical origin.

Metaphonological deficits in developmental dyslexia

The centrality of phonological deficit in spite of variation in orthographic patterns and strategies of literacy acquisition leads to the assumption that both alphabetic (English) and alphasyllabic (Oriya) would impose similar constraints of grapheme to phoneme conversion on dyslexic readers. A core deficit in developmental dyslexia is the accurate specification and neural representation of the amplitude envelop onsets of speech and this may be causally connected to deficits in metaphonological processing (Goswami et al 2002). Recent survey of literature on dyslexia suggests that at some level young children with developmental dyslexia show deficits in metalingusitic awareness of their spoken languages tested in a varieties of tests designed to tap that knowledge. This deficit is then casually linked to explain their eventual inability in learning

to read and acquiring other written language skills. This refers to the ability to progress from the transparent to the opaque forms of language and to attend these forms in and themselves. It is the gradual shift of attention from meaning to structure or from linguistic content to linguistic forms and denotes implicit knowledge that is made explicit through training. More specifically it is the ability to conceptualize, reflect on and manipulate the sub-lexical segments of spoken language in terms of phonemes, syllables and other global units, which plays a direct role in reading development.

Syllabic or phonemic awareness – The case of Indian languages
Syllables play a central in speech planning and speech production and are involved at the interfaces of phonological and phonetic encoding (Cholin et al. 2006). Since overt reading involves grapheme to phoneme conversion and then articulation, it is logical to assume that syllables too play a dominant role in reading particular types of words of different sizes and complexity. Words and non-words with different syllabic structures would affect differently the reading processes in dyslexics and non-dyslexics (Zoccolotti et al. 2005). Sensitivity to syllabic structures also has been shown to develop early compared to other units of spoken language in children who are hearing impaired who use phonological syllables as reading units suggesting its fundamental importance in the organization and development of speech. However there is a danger is assuming that the purely linguistic units of spoken language like phonemes, syllables and words would generate their corresponding cognitive objects in the processing of written language. Deficits in dyslexic's reading performance could be at the level phoneme, syllable or in manipulation of bigger entities like words. It has been suggested that phonemes being the smallest units of spoken language and less acoustically pure are difficult for the dyslexics to manipulate than syllables that are acoustically more real and less abstract (Spector 1995). Hence it seems that constraints in reading could be at any level of manipulation of the spoken units of language and may significantly depend upon the type of orthography. As compared to English where the grapheme to

phoneme conversion is less direct, Indian language orthographies show more regular mapping (Karanth 2002). However, this does not mean that this regularity helps dyslexics read better or with less errors as incidence of dyslexia in regular orthographies is also quite significant (Vellutino et al 2004; Zoccolotti et al 1999). It is hypothesized that in spite of the type of orthography, there would be deficits in the phonological domain and this deficit would quantitatively and qualitatively vary between a *phoneme* based awareness as in case of purely alphabetic languages like English and a *syllable* based ability in alpha-syllabic languages like Oriya and other Indian languages.

This particular study was designed to tap the deficits in Oriya developmental dyslexics on a battery of metaphonological tasks that explored the phoneme and syllable based knowledge differently. It was hypothesized that since Oriya orthography is regular as far as grapheme to phoneme conversion is concerned this may facilitate the dyslexics in their decoding ability differently on *syllable* and *phoneme* based manipulations. The other aim was to quantify the effect of increasing syllabic length and phonological complexity on the reading of real and non-words in children with developmental dyslexia. It was hypothesized that as the numbers of syllables increase there is a corresponding increase in the overall phonological complexity of the words and non-words and corresponding decrease in the reading performances. This effect will be more evident in the dyslexic group than in the controls who because of their excellent metaphonological skills would efficiently read even words with bigger lengths. Of course, there is the component of working memory involved in any discussion of the effect of increasing length on reading words, which cannot be denied. The results have been discussed in the currently accepted framework of phonological deficits in dyslexia and reveal certain unexpected components that require further empirical investigations in different Indian languages.

METHODS

Subjects

20 developmentally dyslexic Oriya primary grade (Age range 8-9 years) were selected from a large sample survey of 250 children

in different schools located in Rourkela, Orissa. The children were from government run primary schools with Oriya as the medium of instructions. Only monolingual Oriya speaking children were selected to identify potential children with a specific developmental reading deficit. The following tools were used for the selection of developmental dyslexics. The complete description of the tools and cut of scores are discussed in Mishra (2005). However brief descriptions of the tasks are given below.

Tests used for identification of developmental dyslexics

(A)

1. *The Raven's Colored Progressive Matrices (RCPM)*
This is a non-verbal test used to access the IQ of the children. Only children with a percentile of >70 were selected for later tests, as an above than average IQ has been a crucial element in the diagnosis in dyslexia.
2. *Rutter's performa*
This has 25 questions in it for eliciting the opinion of the class teacher (who taught Oriya language) about the behavioral stability of the individual child. Children who had a score below than 9 were considered as it could be inferred that their impairment in reading was not because of a low IQ or other behavioral elements.
3. *Family questionnaire*
This questionnaire was developed to have the opinion of the parents on their children's ability in different domains of literacy such as reading, writing, verbal comprehension, mathematical ability, and handedness. The information was coded and analyzed for selecting candidates with developmental dyslexia.

(B)

The following reading and comprehension tasks were administered to the selected children who fulfilled the criteria for IQ, Rutter's Performa and whose parents had explicitly remarked about the possible presence of a reading deficit as could be analyzed for the family questionnaire. Thus from the initial 250 children only 60 children could be included for later

administration of reading tests. Hence at this stage it was certain that these selected children who were other were normal with high IQ had a specific reading disability thus making them a right set of candidate for further testing of phonological deficit hypothesis.

1. *Paragraph reading*

A passage of ten sentences of uneven length with words varying from two to five syllables and having all the admissible consonant clusters of Oriya language was selected from the class Vth language book. It was expected that children would be able to read the passage without much difficulty as they already had enough of literacy education by this time. Number of correctly read words and errors were noted for analysis. The idea was to test reading competence in context as opposed to isolated reading of words.

2. *Reading of word list*

Fifty words with different syllabic structure were selected from the language book for isolated reading. If the child could not read more than ten words consecutively then the test was abandoned.

3. *Listening comprehension*

This was designed to test the verbal comprehension ability in the children. It consisted of eight sentences of a story and subjects were asked five questions to test their auditory comprehension of the passage. This helped in observing children who had significant deficit in auditory comprehension which could be a distinct deficit because of limited verbal working memory a high level linguistic deficit.

After the sequential administration of the above battery of tests only twenty-five children fulfilled the accepted criteria of having a specific developmental reading impairment who otherwise did not have any evident neurological, psychiatric or behavioral problem and who had a good IQ. Another 25 normal age and IQ matched children were selected from the original pool to serve as control group in the main tasks.

Tests used for metaphonological awareness and syllabic complexity

The metaphonological tasks were divided into phoneme based and syllable based as it was the aim of the study to see if there was indeed a significant disparity in performance on these two distinct units of spoken language in developmental dyslexics. Since Oriya is a regular language with perfect mapping between graphemes and phonemes it was expected that dyslexics would not find it much difficult to perform manipulations on the phoneme based tasks. However, the performance on the syllable-based tasks was expected to be much better than the phoneme based tasks, as already noted syllables are acoustically less abstract compared to phonemes. For the detailed descriptions of the individual tasks and other criteria in interested reader may refer Mishra (2005).

(A) *Phoneme based tasks*

1. *Phoneme deletion*

10 bisyllabic and 10 trisyllabic Oriya words from the language textbook were selected and auditory presented. The subject was instructed to say the rest of a word after deleting a target phoneme.

2. *Phoneme counting*

10 bisyllabic and 10 trisyllabic words were auditorily given to listen and subjects were asked to count the number of individual phonemes present.

3. *Vowel change*

There were 10 bisyllabic and 10 trisyllabic words with one or more vowels. The subject was to listen carefully and then change the vowels in the word into another target vowel and say the new word. The resultant word often was a non-word.

4. *Phoneme oddity*

This test consisted of 20 stimuli each having four bisyllabic non-words of which three had the initial or final sounds common. The subject had to point out the words, which had a different sound all together from the rest, and thus which was the odd phoneme sound in that sequence.

B. *Syllable based tasks*

1. *Syllable deletion*

10 bisyllabic and 10 trisyllabic words were auditorily administered for deleting a syllable and saying the rest of the word

2. *Syllable reversal*

The subject had to listen 10 bisyllabic and 10 trisyllabic words and then reverse the syllables.

3. *Rime recognition*

There were 20 bisyllabic words out of which 10 rhymed and other 10 did not rhyme. The subject had to say whether the word presented rhymed or not.

4. *Syllable counting*

There were 10 bisyllabic and 10 trisyllabic words. The subject had to count number of syllables.

Tests used as measure of syllabic complexity

This test had 100 real words and 100 non-words divided into the following syllabic types. The subject had to read aloud each word correctly. Words and non- words (each 20 in number) were prepared of gradually increasing in syllabic length such as CVCV, CVCCV, CVCVCV, CCVCVCV, CVCCVCV and CVCCVCVCV.

RESULTS

Metaphonological tasks

The performance of developmental dyslexics and normal control children on different metaphonological tasks is summarized in Figure 1. The mean values on each task with standard deviation values are represented in each bar. It is clear that dyslexic's performance on all the tests are generally poor across tasks compared to the controls indicating that metaphonological awareness of spoken language is severely affected because of developmental dyslexia. Performance on phoneme based tasks such as on phoneme counting, phoneme oddity, phoneme deletion and vowel change was significantly different ($p < 0.05$). It is interesting to note that dyslexic's performance is highest on the

task of syllable counting (SC) and lowest for Phoneme Oddity (PO). This could be because of syllables being the easiest units of spoken language to manipulate auditory compared to phonemes.

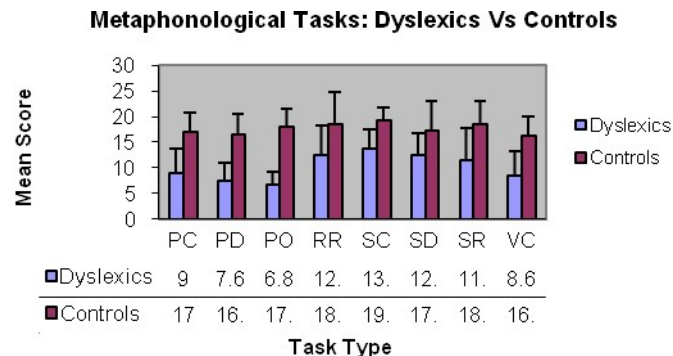


Figure 1. Shows mean scores with *Sdv* values as bars of dyslexics and controls on metaphonological tasks. PC [phoneme counting], PD [phoneme deletion], PO [phoneme oddity], RR [rhyme recognition], SC [syllable counting], SD [syllable deletion], SR [syllable reversal], VC [vowel change]

Performance in syllable vs phoneme based tasks

Figure 2 shows the performance of developmentally dyslexic children on syllable based metaphonological tasks compared to phoneme based tasks.

It was of interest to explore developmental dyslexic's metaphonological skills independently on phoneme and syllable based tasks. For this purpose tasks such as Phoneme Counting (PC), Phoneme Deletion (PD) and Phoneme Oddity (PO) were considered as *phoneme* based since in all these tasks the basic unit of manipulation was a single sound. Similarly, tasks such as Syllable Counting (SC), Syllable Deletion (SD) and Rhyme Recognition were grouped together as *syllable* based as they all shared syllables as their basic unit of manipulation. It was hypothesized that in a regular orthography like Oriya with excellent grapheme to phoneme conversion, children with developmental dyslexia would show dissociation in their ability to manipulate a syllable compared to a phoneme, which would be

reflected in their task scores. It was observed that indeed the performance of dyslexics on syllable-based tasks was far superior compared to phoneme-based tasks ($p < 0.05$). The performance of control children on syllable based and phoneme-based tasks were almost similar as could be seen from Fig. 1. However, in children with developmental dyslexia who learn to read Oriya the ability to cognitively manipulate a syllable appeared greater than phonemes. The possible explanation of these findings is explained in the discussion section.

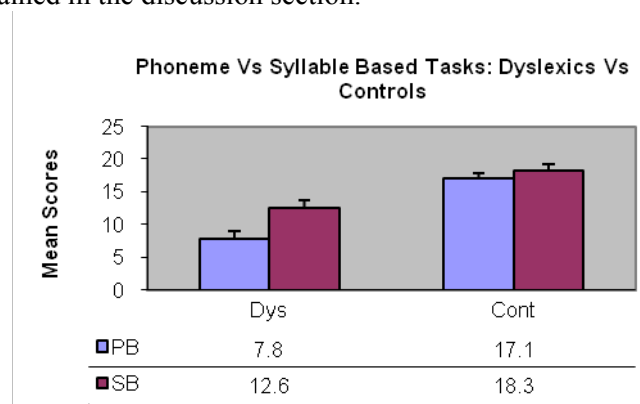


Figure 2. Comparison of Phoneme based tasks [PB] with Syllable based tasks [SB] between dyslexics and controls. Phoneme based tasks included Phoneme counting, phoneme deletion and Phoneme oddity. Syllable based tasks included syllable deletion, syllable counting and syllable reversal. Performance was averaged across tasks of each type. Mean scores are on the y-axis and bars denote Sdv

Syllabic constraint and reading

The central goal of this experiment was to explore the effect of increasing syllabic length on the reading performance of words and non-words in children who have been identified with developmental dyslexia compared to a group of age and IQ matched normal children. Figure 3(a) shows the performance of dyslexics and controls ($p < 0.01$ for all comparisons) on sets of real words and non-words organized into different syllabic types increasing in length thus becoming phonologically more

complex. The results indicate that dyslexic's performance is poor on all the syllabic levels on real and non-words compared to controls. The performance is best when the words are CVCV and it is worst when it is CVCCVCVCV, which was expected. Clearly the performance is better on real words than non-words even between stimuli belonging to the same syllabic level. The results agree with the observation of Ferrand (2000) and Zoccolotti et al. (2005), who showed a strong syllabic length effect in the reading of mono and polysyllabic words in dyslexics linking the problem to a multiple trace model of polysyllabic words representation. Children in the control group show more or less a steady performance in readings of real and non-words in spite of changes in the syllabic length. Figure 3(b) captures the fall in reading scores as syllabic length increase for real words and non-words in children with dyslexia and controls.

Syllabic Complexity and Reading: Controls

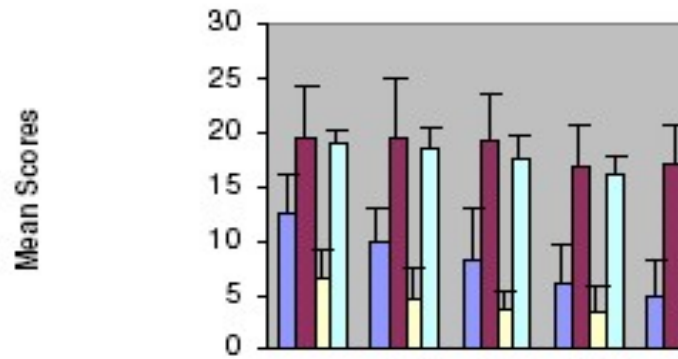


Figure 3(a). Dyslexic and control group performances on the reading of words and non-words of varying syllabic length. RW (Real words) and NW (Nonwords). Individual bars show mean scores on each syllable type of a particular word type along with the error bar denoting Standard deviation. Bars of different colors represent dyslexics and control

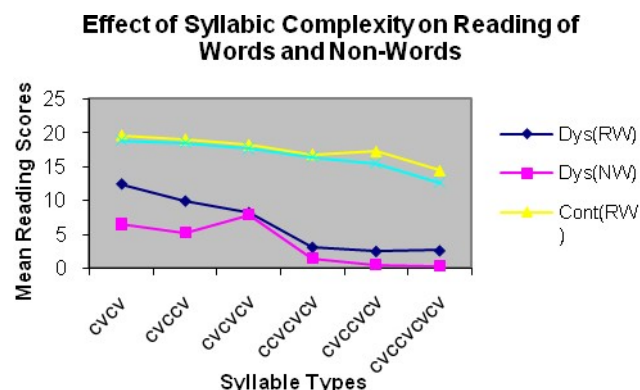


Figure 3(b). *The effect of increasing syllabic length of reading of real words and non-words in developmental dyslexics and controls. Note that the rate of decrease is less in real words than non-words. Dys [Dyslexics], Cont [Controls], RW [Real Words] and NW [Non-Words].*

DISCUSSION

The investigation of what is the extent and the nature of dyslexia, what dyslexics know and understand of linguistic knowledge, and what dyslexics largely manifest began in the later half of the twentieth century. The idea of phonological deficit of spoken language and its casual connection with development of literacy has since been applied to experimental situations in different languages and cultures. Studies on developmental and acquired forms of reading in several Indian languages with their alpha-syllabic scripts have revealed a different nature of dyslexia as compared to conclusions drawn from investigations in alphabetic scripts and reading (Karanth 2002; Sharma et al. 2003; Prakash & Sunita 1998; Mishra 2002, 2005). It has been a recent trend to posit evidences of dyslexic's reading and other metaphonological abilities in so called "regular" orthographies against a large body of findings on children's performance in English, the only language where dyslexia has been studied most and widely to make the point that in regular orthographies the performance

pattern of dyslexics is different. From this point of view the present study is unique in testing the idea of metaphonological deficits in developmental dyslexic children in a relatively less studied language like Oriya with a rigorously selected developmental dyslexic population. A small sample size might not be helpful for a strict generalisation of dyslexic's deficits but the trend in performance deficits is clearly demonstrated which further could be replicated in large group studies. We used an experimental design where real and non words with varying syllabic length and phonological complexity were used to tap the effect of syllabic complexity on word reading to demonstrate the effect of syllabic length on word reading. Many experimental works on reading have focused on monosyllabic word reading and have got diversified results (Coltheart, Curtis, Atkins & Haller 1993; Seidenberg & McClelland 1989). However only a very few studies have used multisyllabic words to observe the effect of length on word reading in normal readers (Ans, Carbonnel & Valdois 1998; Ferrand & Segui 2003; Jared & Seidenberg 1990). The seminal work of Spoehr and Smith (1973) suggests that syllable-sized units play a role in visual word recognition. These evidences support the findings of this study, where it was observed that general phonological deficits could be separated into a "syllabic" deficit and a "phonemic" deficit, which may appear in dyslexic children depending upon the type of orthography.

What does a better capacity to manipulate "syllables" in a regular orthography indicate as opposed to performance on "phonemes" and how it develops in young children? This causality is yet difficult to explain based on the few published results on dyslexic's manifestation in Indian languages. Actually, vocabularies of word's language show few monosyllabic words compared to a wide range of multisyllabic words making it compulsory for beginning readers to master such words. The present study demonstrated explicitly the effect of syllabic length of reading and the dissociations observed between real and non-words in developmental dyslexia. Non-word reading has been traditionally used as a diagnostic measure of dyslexia. Poor performance on non-word reading compared to real words in

developmental dyslexics could be because of the fact that non-words are not accessed through a lexical route (Coltheart et al. 1993). Reading strategy of dyslexics to read complex real and non words differently as has been the case with other studies (particularly the Dual Route Model of Coltheart which proposed a lexical route for words and a sub lexical route for non words – Coltheart et al 1993) could not directly be applied in the case of Oriya which has a regular orthography as opposed to English. Moreover the model is based on analysis of reading in English language where reading through lexical and sub-lexical routes is clearly established. The only rational explanation that can be advanced based on the results obtained in this study is that children with developmental dyslexia in Oriya language obviously show deficits in reading of words and non-words along with a competence for syllable based manipulations compared to phonemes. However it could be said that there might be some involvement of working memory as dyslexic children show shorter spans for processing for longer stimulus (Poblano et al 2000). The difficulty in reading words with longer syllables may be a result of deficits in the visuo-spatial and phonological loop alterations in dyslexic children (Poblano et al 2000; Rapala & Brady 1990; Bradley & Bryant 1981).

Another most important result of the study was the dissociation between dyslexic's performances on phoneme-based tasks as compared to syllable-based tasks. The simplest explanation is, syllables are the least abstract and perceptually more distinct units of spoken language compared to phonemes. Syllables have been recognized as fundamental units of word production. The same is not true for phonemes which are psycholinguistically more abstract units as far as perceptual computation is concerned making it thus difficult for the dyslexic to manipulate. This is clearly demonstrated in the obtained results where dyslexic children show a far improved performance on syllable-based tasks. Results obtained in this study of dyslexics performance on syllable based tasks agree with the findings of Ziegler & Goswami (2005) who show that in many languages such as Turkish, Italian, Greek, French younger readers acquire the knowledge of syllable first then phonemes as

these language have regular grapheme to phoneme correspondence. Based on these cross linguistic observation of emergent syllabic awareness in regular orthographies, it is argued that in regular languages young readers move from a broader “syllable” awareness stage to more narrower “phonemic” awareness. However this proposal requires more empirical evidence.

Could this “syllabic” advantage be because of the nature of Oriya orthography itself? There cannot be a straightforward answer to this question yet based on these limited results. However it will be argued here that if syllables are easier to manipulate than phonemes in regular orthographies (As in Oriya and other Indian languages) than there is no justification in testing the “phonemic” awareness of such children as opposed to “syllabic.” Rather the focus of dyslexia discussion in Indian languages should be on “syllabic awareness deficit” rather than “phonemic awareness,” which has an origin from studies on English language. Moreover till date there is no study, which shows the casual interaction of “syllabic awareness” and “phonemic awareness” in the development of reading or how they are differently manifested in dyslexia. The results of the current study attempts to show such an interaction in readers of a regular orthography like Oriya, which require further experimental validation. Dyslexic’s reading deficits has also been found in many other Indian languages such as Hindi where despite the transparency of the Hindi script, dyslexic readers of Hindi have difficulty in developing high-quality, segmentally organized phonological representations of words and display poor blending skills. (Gupta & Jamal 2006; Gupta 2004) which appears as severe a condition as it is in a highly irregular orthography like English.

CONCLUSION

The results of the experiments presented in this study demonstrate that Oriya primary school children identified with developmental dyslexia show serious deficits on metaphonological tasks and reading of words and non-words

with longer syllables. There is observable dissociation in performance on “syllable” based tasks compared to “phoneme” based tasks suggesting that “syllabic awareness” in such readers is better than “phonemic awareness.” This is an important finding which support the emerging view that syllables not phonemes are fundamental units of word recognition and production. Oriya children with developmental dyslexia also show a hierarchical pattern of deficit on reading of real and non-words because of increase in syllabic length and phonological complexity. The overall deficits observed in this study conforms the current “deficit” models of dyslexia as a complex linguistic-cognitive impairment that requires further detailed large scale studies in different Indian languages.

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