ISSN 1799-2591
Theory and Practice in Language Studies, Vol. 14, No. 7, pp. 2161-2172, July 2024
DOI: https://doi.org/10.17507/tpls.1407.24

Development and Validation of Phonological Processing Assessment Tool in Kannada Language

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***Abstract*—The research evidence in orthographically transparent language Kannada indicates that phonological processing significantly influences reading acquisition, and deficits increase the risk of dyslexia. A comprehensive assessment of phonological processing that includes phonological awareness, phonological memory, and phonological naming is crucial for implementing effective intervention strategies, thereby reducing the risk of dyslexia. However, there is a notable absence of phonological processing assessment tools specifically designed and validated for children learning to read alphasyllabary Kannada. The present study addresses this gap by developing and validating a phonological processing assessment tool for children between Grade I and Grade III learning to read alphasyllabary languages such as Kannada. The study was conducted in two distinct phases. The first phase consisted of developing and piloting a phonological processing assessment tool. It included the stages of task selection, item generation, content validation, pilot testing, and reliability analysis. In the second phase, the developed tool was validated by administering it to both typically developing children and children at-risk for dyslexia from Grade I through Grade III. Subsequently, the developmental appropriateness of the tool was tested by comparing the performance of typically developing children between the grades. Additionally, diagnostic validity, including sensitivity, specificity, and area under the curve, was established by comparing the performance of typically developing and at-risk children. The study makes a substantial contribution to research on reading in Akshara orthographies, offering a valuable clinical tool for identifying children at-risk for dyslexia.**

***Index Terms*—phonological processing, phonological awareness, phonological naming, phonological memory, Akshara orthographies**

I. Introduction

Phonological processing is a fundamental cognitive-linguistic skill for children's language acquisition and literacy development. It is one’s metalinguistic skill of utilizing the phonological information, especially the sound structure of one's oral language, in processing written and oral information (Anthony et al., 2006, 2007). According to Catts et al. (1999), phonological processing refers to the perception, storage, retrieval, and manipulation of the sounds of language during the acquisition, comprehension, and production of both spoken and written codes. Wagner and Torgesen (1987) proposed a comprehensive framework for phonological processing, positing three distinct yet interconnected phonological dimensions such as phonological awareness, phonetic encoding in working memory or phonological memory, and phonological recoding in lexical access or phonological naming. Cassano and Steiner (2016) define phonological awareness as the “ability to detect, manipulate, or analyze the components of spoken words such as syllables, onset-rimes, and phonemes, apart from consideration of their referents” (p. 1). Phonological memory codes acoustic information in a sound-based representation system for temporary storage, generally assessed using memory span tasks. Lastly, phonological naming is the rapid retrieval of phonological codes from long-term memory, usually

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assessed through Rapid Automatized Naming (RAN) of letters, objects, colors, or digits. All three skills are cognitively distinct and evaluate the same area of language subsumed within the construct of phonological processing. However, the contribution of phonological processing to reading acquisition is of substantial theoretical and practical importance.

A. Theoretical Foundation

Phonological processing skills significantly impact literacy development in children, mutually enhancing the acquisition of reading skills (Swaroopa & Prema, 2001). Studies in alphabetical languages like English consistently reveal that critical reading skills such as word recognition, fluency, and comprehension heavily rely on phonological processing abilities (Nelson et al., 2012). Phonological processing plays a significant role in reading acquisition and, therefore, is regarded as a primary cognitive determinant of word reading (Share & Stanovich, 1995). It predicts reading skills and plays a causal role in reading development (Anthony et al., 2007; Loucas et al., 2016). Longitudinal and correlational research consistently identifies phonological processing skills as the strongest predictors of reading development, with phonological awareness particularly highlighted (Caravolas et al., 2013; Clayton et al., 2020; Melby-Lervåg et al., 2012). Some others have shown phonological memory as the unique predictor of reading (Maridaki-Kassotaki, 2002; Nevo & Breznitz, 2011) and also indicated that children with reading impairment have poor phonological short-term memory skills (Fischbach et al., 2014; Schuchardt et al., 2013). Other studies have shown RAN as a significant predictor of reading (Wolff, 2014).

Diverse evidence converges, suggesting that Developmental Dyslexia (DD) can be characterized by observable deficits in phonological awareness, short-term memory, and naming (Rack et al., 1992). Ramus and Szenkovits (2009) clarified the commonalities that underlie these three constructs, elucidating how phonological representations are implicated in distinct yet interrelated ways. The impairments within these "triads" constructs signify deficiencies or degradation of phonological representation frequently observed in children with developmental dyslexia (Boada & Pennington, 2006; Farquharson et al., 2014). According to the phonological processing deficit hypothesis, a core deficit in phonological processing abilities is a plausible cause for word-level reading problems or dyslexia (Ramus et al., 2003; Vellutino et al., 2004). The findings of the systematic review verified that the phonological processing deficits model for explaining dyslexia in all types of writing systems, such as ideographic, syllabic, and logographic, as well as alphabetic orthography, with different levels of orthography phonology consistency (Navas et al., 2014).

Converging lines of evidence suggest that DD can be characterized by one of several phenotypic manifestations of a phonological deficit (phonological awareness, Phonological Short-term Memory (PSM), phonological naming assessed using RAN). The impairment in single or multiple components of phonological processing abilities among children with developmental dyslexia has been observed in diverse orthographies exhibiting different levels of transparency, such as English (Vellutino et al., 2004), Dutch (Knoop-van Campen et al., 2018), French (Maïonchi-Pino et al., 2010), German (Steinbrink & Klatte, 2008), and Chinese (Cheng et al., 2021).

B. Study Context and Need

The role of phonological processing in learning to read more consistent Indic orthography represented using Akshara has also been widely investigated in different languages spoken across the Indian sub-continent, including Kannada (Nag, 2007; Nag et al., 2014; Nag & Snowling, 2012; Nakamura et al., 2017) Tamil (Paramadhyalan, 2015), Telugu (Nakamura et al., 2017), Malayalam (Joy et al., 2023; Somashekara et al., 2014), Marathi (Singh & Sumathi, 2019), Hindi (Gautam et al., 2019), Punjabi (Gautam et al., 2019), and Bengali (Sircar & Nag, 2013). Several studies involving poor readers of Akshara orthographies have confirmed the phonological processing deficits in one or more domains in children with developmental dyslexia (Gupta, 2004; Khan & Bajre, 2018; Nag & Snowling, 2010; Nag-Arulmani, 2003; Wijayathilake & Parrila, 2014). The extensive empirical research validates the importance of phonological processing, whether considered as a cohesive construct or individual skills, in acquiring literacy skills across various orthographic systems. These consistent findings persist even within Akshara-based orthographic systems, as previously elucidated. Consequently, they have been incorporated into screening and diagnostic instruments to identify children with dyslexia or reading disabilities. Considering the theoretical, research, and clinical implications of phonological processing skills in reading, numerous tests have been developed and validated in many languages spoken worldwide.

The languages vary in phonology and orthography, thus necessitating language-specific assessment tools to facilitate identifying and remedying children with reading disabilities. The Kannada orthography has greater consistency in orthography to the phonologic mapping of units. It is more transparent than the Alphabetic language of English. Kannada, one of the prominent Dravidian languages, is predominantly spoken in the Indian state of Karnataka. It is the state's official language and is spoken by a population exceeding 60 million. The children in schools of Karnataka are taught to read and write Kannada right from the onset of formal literacy training in private and public schools. Most studies conducted in Kannada have used investigator-developed assessment tasks and lack psychometric properties. The assessment tasks have been the least standardized across the studies conducted in the Kannada language, and validated for content, development, and diagnostic accuracy. For example, phonological awareness tasks can vary in many dimensions, including the phonological unit, the position of the linguistic unit within the word, cognitive operation, the mode of stimulus delivery, and stimulus comparison. The variation in the task may lead to divergence in the results and compromise the sensitivity and specificity of the assessment tool in identifying children with reading disabilities. Hence, the present study aims to develop and validate phonological processing assessment tools in orthographically transparent Akshara orthography Kannada.

II. Method

The research protocol received approval from the Institutional Ethics Committee, Kasturba Medical College, Mangalore. A cross-sectional study design and convenient sampling method were employed to select the participants. The study was conducted in two phases.

A. Phase I - Test Development and Pilot Testing

The construct of phonological processing encompasses a spectrum of language-based skills. The conceptual framework for identifying crucial domains encompassed by the overarching concept of phonological processing was grounded in the seminal investigations and extensive reviews by Wagener and Torgesen and the publication of the Comprehensive Test of Phonological Processing (CTOPP) (Wagner et al., 1999). The researcher-designed developmentally appropriate and clinically relevant tasks for the assessment tool were derived from the studies in Akshara orthographies (E.g., Nagaraja & Sampathkumar, 2016; Nakamura et al., 2014, 2017; Siddaiah et al., 2016; Siddaiah & Venkatesh, 2014; Wijaythilake et al., 2019) and comprehensive analysis of widely used assessment tools. These instruments include the Comprehensive Test of Phonological Processing (CTOPP) (Wagner et al., 1999), Phonological Awareness Test-2 (PAT – 2) (Robertson & Salter, 2007), Phonological Abilities Test (PAT – M) (Muter et al., 1999), Rapid Automatized Naming (RAN) (Denckla & Rudel, 1974). A pool of 400 Kannada words was selected from school books with syllables ranging from two to six with CVCV syllable structure and validated for children familiarity by three classroom teachers rating the item using a 5-point rating scale through a continuum of familiarity from 'not at all' to 'extremely familiar.' Words with consistent moderate and high familiarity ratings were chosen and allocated to each task. The phonological awareness task complexity varied in three dimensions, including linguistic unit (syllable, rime, and phoneme), cognitive operation (segmenting, blending, and manipulation), and position of the target linguistic unit within the word (initial, medial, and final) in manipulation tasks. The complexity of blending and segmentation tasks was increased by increasing the syllable length of the word from two to five syllables.

Conversely, words comprising two to three syllables were opted for tasks assessing phoneme awareness, given that phoneme awareness emerges slowly compared to syllable awareness according to the developmental data in the Kannada language. However, for syllable/phoneme manipulation tasks, the complexity was increased by varying the position of the target syllable/phoneme within the stimuli words, such as word-initial, medial, and final position. The rhyme oddity and production task stimuli consisted of bi/tri syllable words. The number of test stimuli under each task was unequal and vast before content validation by experts and a pilot study.

All the tasks had three practice items, followed by ten test stimuli. For both phonological awareness and phonological memory, the tasks were administered in the auditory modality, the response eliciting modality was verbal, and the response format was verbally constructed responses. The RAN-O was administered visually, elicited responses were verbal, and the response format was verbally constructed responses. Scoring for all phonological awareness tasks was based on the accuracy of responses, where correct answers were assigned a score of '1' and incorrect answers were given a score of '0'. In the case of Rapid Automatized Naming (RAN) tasks, naming speed was measured. It is the total time the child takes to name all items on the sheet.

Once the initial set of tasks and stimuli (trial and test items), with instructions and scoring procedures, were finalized, the designed assessment tool was subjected to content validated by five Speech-Language Pathologists (SLPs) with ten years of experience. The experts validated the contents, including task, instruction, stimuli, and scoring procedures, using a 5-point Likert's rating scale to gauge the appropriateness. The scale ranged from '0' for absolutely inappropriate, and '4' indicated appropriate. The content-validated assessment tool was piloted on a small sample group of children with characteristics similar to those of the participants in this study. A total of thirty, ten each from every Grade, were randomly selected, and the test was administered individually. The mean performance across all the tasks except phoneme awareness tasks depicted the sensitivity to age. The floor effect was observed for syllable addition and substitution in the medial position and all the phoneme awareness tasks; hence, it was excluded from the assessment tool. However, the responses for each item for the rest of the tasks were carefully analyzed across grades based on item difficulty and item discrimination. Items with an item difficulty index ranging from 0.15 to 0.85 were deemed suitable and incorporated into the test, as Wagner et al., (1999) outlined. Likewise, items displaying an item discrimination index of 0.30 or higher were included in the test, following the criteria stipulated by Aiken and Groth-Marnat (2006). Subsequently, both test-retest and inter-rater reliability were established.

The finalized assessment tool included 14 tasks classified into different dimensions. The phonological awareness tasks included Sentence Segmentation (SS), Syllable Segmentation (SyS) and Blending (SyB), Syllable Stripping at Initial (ISSt), Medial (MSSt), and Final (FSSt) positions, Syllable Addition at Initial (ISA), and Final (FSA) position, Syllable Substitution in Initial (ISS), and Final (FSS) positions, Rhyme Oddity (RO), Rhyme Production (RP)**.** All the tasks included 10 meaning words as stimuli, auditory modality of presentation, oral modality of responding, and scoring for accuracy of response as '0' for incorrect and '1' for correct responses. The phonological naming included Rapid Automatized Naming (RAN) of objects (RAN-Objects) task. It consisted of five bi-syllabic pictures of familiar objects such as /mi:nu/ (fish), /hu:vu/ (flower), /tʃʰʌt̪ɾi/ (umbrella), /se:bu/ (Apple), and /mane/ (house). These images were repeated ten times and arranged randomly in ten rows and five columns, constituting fifty items. The items were printed on A4 size paper for visual presentation. A trial card was prepared to familiarize the task, consisting of five items repeated four times in two rows and ten columns randomly. The child was instructed to begin naming the objects from the upper left top corner and progress row by row until the lower right corner of the page and the total time calculated. The phonological memory was assessed using a pseudoword repetition task. The pseudowords were generated by either interchanging the syllable positions or substituting a syllable (CV structure) or phoneme (either C or V) within the meaningful words ranging from two to five syllables without violating the phonotactic constraints of Kannada language (Patel et al., 2022). The complexity of the test stimuli for pseudowords was increased by increasing the length of syllables from monosyllable to multi-syllable pseudowords while varying syllable structure from simple (CVCV) to complex (CCV).

B. Phase 2- Validation

(a). Participants

The study included both typically developing children and children at-risk for dyslexia. In order to evaluate the developmental appropriateness, a typically developing group included a total of 300 children, 100 each from Grade I, Grade II, and Grade III, with the corresponding Grade-specific age ranges of 5.6 to 6.6 years, 6.7 to 7.6 years, and 7.7 to 8.6 years respectively were selected. Similarly, a small age-matched group of children at-risk for dyslexia was included to evaluate the diagnostic validity of the assessment tool. It comprised 26 children, each from Grade I to III, with an equal male-to-female ratio. The children were selected from twelve public schools in the Dakshina Kannada district of Karnataka, with a curriculum affiliated with the Karnataka state board. The demographic details of typically developing and children at-risk for dyslexia are shown in Table 1. The participants were selected based on the predefined inclusion and exclusion criteria for typically developing and children at-risk for dyslexia. The typically developing children fulfilled the inclusion criteria by demonstrating age-appropriate language development as assessed by the 'Assessment of Language Development' test (Lakkanna et al., 2021). Additionally, they had attended preschool for a minimum of two years. They belonged to families with a middle socio-economic status according to the Kuppuswamy socio-economic status rating scale (Kumar et al., 2022), with parents achieving a minimum literacy level equivalent to completing class 10th. Only the children who passed the Dyslexia Assessment for Languages of India - Junior Screening Tool (DALI- JST) were included.

TABLE 1
DEMOGRAPHIC DETAILS OF TYPICALLY DEVELOPING CHILDREN AND CHILDREN AT-RISK FOR DYSLEXIA

Group	Grade	n	M (Years)	SD (Months)
Typically developing children	I	100	5.10	0.3
	II	100	6.11	0.4
	III	100	7.10	0.3
Children at-risk for dyslexia	I	26	5.80	0.3
	II	26	6.10	0.3
	III	26	7.11	0.2

The exclusion criteria for both typically developing and children at-risk for dyslexia was the same, where children with documented histories or complaints of significant speech, language, hearing, developmental, intellectual, or neurological disorders, as determined through the implementation of the WHO ten-question disability screening checklist (Singhi et al., 2007) were excluded. Additionally, the children who had experienced class retentions, irregular school attendance, and changes in the medium of instruction according to the school record were excluded. However, the at-risk children were selected based on the teachers scoring the child with significant difficulties in literacy skills using the Dyslexia Assessment for Languages of India - Junior Screening Tool (DALI- JST) by the Ministry of Science and Technology, Govt of India (2015) in Kannada across the literacy-related areas such as sound awareness, skill acquisition (reading, writing, and number concepts), communication, motor coordination, and behavior based on their close observation for at least six months. Children whose scores exceeded the predetermined cut-off score were categorized as at-risk for dyslexia.

(b). Data Collection

The test was administered after obtaining permission from the school administrative authority and consent from parents towards the end of the academic year. The testing was carried out individually after establishing the rapport. The stimuli were presented verbally using live voice for phonological awareness and memory, whereas, for phonological naming, the stimuli were presented visually using the stimuli cards. All the tasks were initially familiarized with test stimuli before assessment. A constant sequence of testing was maintained across all the participants. The assessment sequence was phonological awareness (word level, syllable level, and rhyme level), phonological memory, and phonological naming.

C. Statistical Analysis

The raw data was subjected to statistical analysis using SPSS 17.0 (Statistical Package for Social Sciences, version 17.0). The assessment tool was subjected to three reliability analysis types: internal consistency using Cronbach's alpha coefficient, test-retest reliability, and interrater reliability using intraclass correlation coefficient. The content validity was assessed by calculating the Content Validity Index (CVI) based on expert ratings. Developmental validity is evaluated by employing the non-parametric Kruskal-Wallis Test to compare the performance of typically developing children across grades, followed by post-hoc pair-wise comparisons using the Mann-Whitney U Test. Diagnostic validity was established by comparing the performance of typically developing children with age-matched 'at-risk' children for dyslexia, using the non-parametric Mann-Whitney test followed by receiver operating characteristics (ROC) analysis to ascertain cut-off scores, sensitivity, specificity, and the Area Under the Curve (AUC).

III. Results

A. Reliability Analysis

The Cronbach's alpha ranged as low as 0.71 and high as 0.94 for phonological awareness tasks. The pseudo-word repetition task had 0.87. However, it was not calculated for the RAN task, as it contained only one item, which is unsuitable for the speeded naming task. Each task exhibited reliability coefficients exceeding 0.70, satisfying the psychometric reliability criteria. The intra-class correlation coefficients, computed to assess test-retest reliability across all tasks, ranged from 0.85 to 0.94. Similarly, for inter-rater reliability, the coefficients ranged from 0.83 to 0.94. All these coefficients were statistically significant ($p < 0.001$).

B. Validity Analysis

(a). Content Validity

A subjective method of content validation was employed, where the SLP validated the appropriateness of tasks, stimuli (trial and test items), instructions, and scoring procedures using a 5-point rating scale. The content validation index (CVI) was calculated for every item by dividing the number of speech-language pathologists providing the desired rating by the total number of speech-language pathologists (Lynn, 1996).

In summary, a rating of '3' or '4' was considered the desired rating as it indicates the higher relevance of a particular item. According to Polit and Beck (2004), the criterion point of CVI is 0.80, and the item with a CVI more significant than or equal to 0.80 was included. The results indicated that all the tasks and scoring procedures received a unanimous rating of 'absolutely appropriate' from the experts, suggesting no further modification. Stimuli items below the CVI threshold were replaced, as experts reported low familiarity with the item among children. The experts expressed concerns regarding the instructions for specific tasks and suggested reframing so that the length and complexity could be further reduced. According to experts, the instructions may impose a load on the working memory, resulting in poor performance.

(b). Developmental Validity

The mean and SD across the grades for phonological processing skills are shown in Table 2. The Kruskal-Wallis test revealed that statistically significant difference between the grades on sentence segmentation ($H(2) = 114.32$, $p=0.000$), syllable segmentation ($H(2) = 176.81$, $p=0.000$), syllable blending ($H(2) = 189.06$, $p=0.000$), initial syllable stripping ($H(2) = 81.70$, $p=0.000$), medial syllable stripping ($H(2) = 171.96$, $p=0.000$), final syllable stripping ($H(2) = 79.19$, $p=0.000$), initial syllable addition ($H(2) = 124.32$, $p=0.000$), final syllable addition ($H(2) = 162.32$, $p=0.000$), initial syllable substitution ($H(2) = 132.32$, $p=0.000$), final syllable substitution ($H(2) = 119.32$, $p=0.000$), rhyme oddity ($H(2) = 167.40$, $p=0.000$), rhyme production ($H(2) = 46.90$, $p=0.000$), pseudoword repetition ($H(2) = 45.22$, $p=0.000$), and RAN-O ($H(2) = 114.65$, $p=0.000$). The subsequent pair-wise comparisons using the Mann-Whitney U test revealed that the performance of Grade III children was significantly ($p<0.05$) higher than those of Grade I and Grade II children in all the phonological awareness tasks. Also, children from Grade II performed significantly ($p<0.05$) better than those from Grade I in all the phonological awareness tasks.

TABLE 2
MEAN, AND STANDARD DEVIATION FOR PHONOLOGICAL PROCESSING SKILLS ACROSS GRADES

Variables	Number of items	Grade I			Grade II			Grade III		
		n	M	SD	n	M	SD	n	M	SD
SS	10	100	4.45	1.14	100	5.5	1.18	100	7.03	1.44
SyS	10	100	6.24	1.56	100	8.68	1.38	100	9.72	0.57
SyB	10	100	5.43	1.83	100	8.82	1.38	100	9.66	0.68
ISSt	10	100	7.32	1.95	100	9.11	1.30	100	9.56	0.67
MSSt	10	100	5.59	1.91	100	8.86	1.87	100	9.85	0.43
FSSt	10	100	8.3	1.62	100	9.27	1.03	100	9.89	0.31
RO	10	100	3.35	2.25	100	5.52	1.91	100	7.23	2.30
RP	10	100	2.14	3.46	100	3.4	2.70	100	5.25	2.85
ISA	10	100	3.32	4.42	100	5.50	3.28	100	7.20	2.53
FSA	10	100	2.40	3.2	100	5.26	2.2	100	7.57	3.2
ISS	10	100	2.50	2.3	100	3.54	2.1	100	5.67	3.1
FSS	10	100	1.14	1.43	100	3.84	2.43	100	5.58	2.36
PwRep	20	100	15.14	2.77	100	17	2.33	100	19.23	1.8
RAN-O		100	1.16	0.23	100	1.01	0.43	100	0.56	0.29

Note: SS = Sentence segmentation; SyB = Syllable blending, SyS = Syllable segmentation, FSSt= Final Syllable Stripping, ISSt= Initial Syllable Stripping, MSSt=Medial Syllable Stripping, ISA = Initial Syllable Addition, FSA = Final Syllable Addition, ISS = Initial Syllable Substitution, FSS = Final Syllable Substitution, RO= Rhyme Oddity, RP= Rhyme Production, PwRep= Pseudoword repetition, RAN-O= Rapid Automatized Naming of Objects.

(c). Diagnostic Validity

The comparison between typically developing and children risk of dyslexia using the Mann-Whitney test revealed a significantly ($p<0.05$) higher performance of typically developing children at every Grade level. The median scores of children at-risk were found to be lower than typically developing children at each Grade level, suggesting the poor performance of children at-risk for dyslexia on all the phonological processing tasks. Although the inferential analyses showed significant group differences in phonological processing, it does not imply that phonological processing tasks can correctly discriminate children 'at-risk' for dyslexia from typically developing children. Therefore, an ROC curve analysis was performed for the NC versus children 'at-risk' for dyslexia. The more accurately a task discriminates between the groups, the higher the AUC value. As shown in Table 3, all phonological processing measures were significant variables for discriminating between the subjects with good to excellent diagnostic accuracy.

TABLE 3
THE RESULTS OF ROC ANALYSIS OF PHONOLOGICAL PROCESSING TASKS FOR GRADE I, II, AND III CHILDREN

	Grades	Cut-off scores	Sensitivity (%)	Specificity (%)	Area Under the Curve (AUC)	p-value
SS	I	≥3.5	83	80	0.83	0.001
	II	≥ 4.5	94	92	0.94	0.001
	III	≥ 6.5	90	89	0.96	0.001
SyB	I	≥ 4.5	82	93	0.81	0.000
	II	≥ 7.5	88	90	0.92	0.000
	III	≥ 8.5	93	94	0.95	0.000
SyS	I	≥ 5.5	82	93	0.82	0.000
	II	≥ 7.5	92	96	0.92	0.002
	III	≥ 8.5	95	92	0.95	0.004
ISSt	I	≥ 5.5	88	90	0.87	0.000
	II	≥ 7.5	92	94	0.92	0.000
	III	≥ 8.5	91	93	0.90	0.002
MSSt	I	≥ 4.5	95	93	0.89	0.000
	II	≥ 6.6	88	94	0.92	0.000
	III	≥ 7.5	89	90	0.94	0.000
FSSt	I	≥ 6.5	84	89	0.83	0.008
	II	≥ 7.5	90	94	0.91	0.004
	III	≥ 9.5	93	96	0.94	0.000
ISA	I	≥ 2.5	92	87	0.83	0.001
	II	≥ 4.5	88	86	0.91	0.001
	III	≥ 6.5	93	90	0.94	0.000
SA	I	≥ 1.5	95	83	0.82	0.001
	II	≥ 3.5	89	94	0.93	0.000
	III	≥ 4.5	88	90	0.96	0.001
ISS	I	≥ 1.5	88	91	0.81	0.001
	II	≥ 2.5	92	88	0.93	0.001
	III	≥ 3.5	96	86	0.94	0.000
FSS	I	≥ 0.5	89	92	0.86	0.001
	II	≥ 2.5	85	93	0.94	0.000
	III	≥ 4.5	90	89	0.91	0.001
RO	I	≥ 3.5	90	94	0.89	0.002
	II	≥ 5.5	89	92	0.92	0.001
	III	≥ 7.5	94	92	0.97	0.000
RP	I	≥ 2.5	96	94	0.89	0.002
	II	≥ 5.5	92	96	0.91	0.004
	III	≥ 7.5	88	95	0.92	0.003
PwRep	I	≥ 11.5	89	94	0.90	0.000
	II	≥ 13.5	88	91	0.92	0.000
	III	≥ 15.5	94	95	0.97	0.000
RAN-O	I	≥ 1.36	87	92	0.88	0.009
	II	≥ 1.22	86	91	0.90	0.001
	III	≥ 0.58	92	97	0.96	0.000

Note. SS = Sentence segmentation, SyB = Syllable blending, SyS = Syllable segmentation, FSSt= Final Syllable Stripping, ISSt= Initial Syllable Stripping, MSSt=Medial Syllable Stripping, RR= Rhyme Recognition, RP= Rhyme Production, PWRep= Pseudoword repetition, RAN-O= Rapid Automatized Naming of Objects.

The level of significance is maintained at p<0.05 level.

IV. DISCUSSION

The present research aimed to construct and validate a phonological processing assessment tool in the Kannada language. The assessment tool development followed a systematic approach, including a literature review for task selection, item selection, and allocation. The adequacy of test content was determined through expert judgments using the Content Validation Index (CVI). The selection of tasks and items adhered to the criteria of CVI established by Polit and Beck (2004), where a threshold of ≥ 0.80 was considered acceptable. The CVI analysis revealed that the tasks assessing phonological awareness, phonological memory, and phonological naming collectively measure a singular construct related to phonological processing, in agreement with previous studies (Nelson et al., 2012; Ramus & Szenkovits, 2009). Additionally, the ICC for test-retest and inter-rater reliability results indicates that the phonological processing had good to excellent reliability. These findings align with earlier observations in developed test materials with good to excellent test-retest and inter-rater reliability for phonological awareness (Muter et al., 1999; Rosner, 1999; Wagner et al., 1999), phonological naming (Wolf & Denckla, 2005a), and phonological memory (Nicolson & Fawcett, 2003).

According to Anthony and Francis (2005), children become increasingly aware of the sound structure of spoken language with age and follow a universal hierarchy of development across all languages. With age, it advances from shallower or larger units, such as words and syllables, to finer or discrete units, such as phonemes. However, they emphasize the variability in the pace of acquisition of this hierarchy across languages. A similar hierarchical development of phonological awareness was also reported in school-age children speaking Arabic (Tibi, 2010). In Kannada-speaking children, Nagaraja and Sampathkumar (2016) reported no statistically significant difference between the grades when syllable awareness was assessed in Grade IV through Grade VI. The performance was at the ceiling as early as Standard IV, indicating mastery over syllable awareness. These findings were complemented and extended by the present research by investigating the sensitivity of phonological processing skills to lower grades. The results indicated grade-related differences in all the syllable awareness skills across the grades. The performance in Grade III was at the ceiling, indicating the mastery of syllable awareness skills across all the tasks. In conjunction with earlier findings, the present research results show that children master syllable awareness skills by Grade III on segmentation, blending, and syllable stripping at the initial, medial, and final positions. The present study reported scores greater than 80% obtained by Grade II for all the syllable awareness tasks, which almost reached the ceiling, depicting mastery of syllable awareness as early as Grade II and Grade III. This finding is supported by Anthony and Francis (2005), who emphasized that a linguistic environment with highly prominent and clear syllable boundaries in the spoken language aids the early development of syllable awareness compared to a linguistic environment with less salient syllables. The early acquisition of syllable awareness has been proven in several languages with prominent syllables in spoken language.

Past studies have evaluated phonological memory using diverse stimulus types such as non-word repetition, digit span, and word span in children, and found age-related increments in the phonological memory capacity (Bayliss et al., 2005; Gathercole et al., 2004) are in line with the observations of this research. Generally, the developmental progressions can be attributed to an increase in the rapidity of sub-vocal articulatory rehearsal while gradually gaining phonological experience. As a consequence of the rehearsal rate, children can actively maintain more items in the phonological store, thereby increasing the functional capacity of the phonological loop. The findings indicate that the naming speed assessed using RAN-O increases significantly with grades. The increase in naming speed indicates that the speed with which phonological codes are retrieved for lexicons from long-term memory increases with age. The findings complement earlier studies on English monolinguals (Albuquerque & Simões, 2010; Wolf & Denckla, 2005b) and Kannada - English biliterates (Siddaiah et al., 2016).

In addition to content validity, the present research investigated construct validity by comparing the performance of typically developing children with those at-risk for dyslexia using a developed phonological processing assessment tool. The results of the Mann-Whitney test indicated that typically developing children outperform children at-risk for dyslexia in terms of phonological awareness, phonological memory, and phonological naming at all Grade levels. These results indicate a clear developmental lag of children at-risk for dyslexia across all the phonological processing skills compared to typically developing children. Specifically, a slower development in phonological awareness among children at-risk for dyslexia could be due to lower linguistic proficiency, especially vocabulary knowledge (Durgunoğlu, 2002). The wider dispersion of phonological deficits in the clinical group indicates a greater risk of developing reading disabilities in subsequent years of academic life. These results complement the earlier proposal that reading disabilities in children stem from deficits in phonological processing (Boets et al., 2013; Ramus & Szenkovits, 2008). A clinically significant sensitivity and specificity of all the phonological processing tasks included in the present research could differentiate typically developing children from children at-risk for dyslexia. These findings are consistent with previous findings that phonological processing assessment effectively identifies the children at-risk for dyslexia observed in alphabetical languages (Hindson et al., 2005; Neilson, 2009; Schneider et al., 2000). There is substantial evidence to advocate that the primary cause of early failure in word decoding would be due to deficits in phonological awareness (Share, 1995; Torgesen et al., 1994). The poor performance of children at-risk for dyslexia indicates the underspecified phonological representations at all levels of phonological awareness, which would have probably affected their ability to convert grapheme to phoneme during word decoding.

The poor performance of the at-risk group on RAN is probable additional deficits besides phonological deficits, earlier theorized as a double-deficit hypothesis by Wolf and Bowers (1999). The findings of the present research support earlier studies that have acknowledged the role of phonological naming in identifying children at-risk for dyslexia (de Jong & van der Leij, 2003; Puolakanaho et al., 2007). According to ROC analysis, RAN-O differentiated typically developing children with at-risk children at high sensitivity and specificity. The developed tool had good diagnostic validity, as indicated by the area under the ROC, which was closer to 1. In addition to double deficits, the children at-risk for dyslexia group underperformed consistently across the grades on phonological memory tasks. The deficits in phonological memory indicate that the children at-risk of developing reading problems are inefficient in coding information in a sound-based representation system for temporary storage. These findings align with other studies that demonstrated a deficit in different aspects of phonological memory leading to reading disabilities in children (Beneventi et al., 2010; Nevo & Breznitz, 2011).

V. Conclusion

In conclusion, the study addressed a critical need for phonological processing assessment tools for Kannada-speaking children. The tool was a robust instrument for evaluating phonological processing skills across different age groups through rigorous content and empirical validation with a sample of Kannada-speaking participants. The validation of this assessment tool demonstrated its reliability and validity in effectively measuring phonological processing abilities in Kannada. In practical terms, this phonological processing assessment tool can be a valuable resource for educators, psychologists, SLPs, and researchers involved in literacy assessment and intervention in Kannada.

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1. Prabhu, M., Shwetha, P., & Somashekara, H. S. (2024). Phonological Awareness and Alphabetic Knowledge in Typically Developing English Language Learners Between the 3.6 to 6.6 Years. *Reading Psychology*, 45(3), 242–260. https://doi.org/10.1080/02702711.2023.2276463

2. Usha, M. N. K., Anil, M. A., Prabhu, S., Bhat, J. S., & Shivananjappa, S. H. (2020). Kannada akshara knowledge in primary school children: measurement of accuracy and reaction time using a cross-sectional study design. *F1000Research*, 9. https://doi.org/10.12688/F1000RESEARCH.23653.1

3. Prabhu, S., Bhat, J. S., & Shivananjappa, S. H. (2018). Development of word awareness skills in typically developing English language learners during early primary grades. *Indian Journal of Public Health Research & Development*, 9(12), 346. https://doi.org/10.5958/0976-5506.2018.01860.0

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