The factors that influence the emergence of prose reading by at risk readers : specific comprehending difficulties

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Abstract. Learning to read written prose requires access to a complex symbolic system that permits the reader to represent the text in a range of ways. The present study examines the multiple areas of knowledge that contribute to acquiring this system by children at the earliest phase of learning to read.

A cohort of 314 first grade students, of whom154 were identified as 'at risk' readers completed a range of reading, psycholinguistic and cognitive tasks. Principal component analysis was used to analyse the components of knowledge that characterised the 'at risk 'and 'good progress' readers. The components for each group of students that correlated with prose reading comprehension and accuracy were identified. These were combined to develop a description of the literacy learning readiness profiles of each group.

Analysis of the knowledge profiles of the at risk group showed several possible causes of reading disability. It was possible that a low score in either reading comprehension or accuracy could be attributed to several possible sources. The implications of the findings for effective intervention are discussed.

Learning to be literate involve constructing an elaborate symbolic system can be used to represent text. This system is linked with other symbolic systems an individual has already begun to construct. These earlier symbolic systems are referenced in the individual's formative experiences and are defined by one's culture. They include the young child's knowledge of oral language, imagery and meaningful gestures. Individuals use these and their early experiences with text to construct their literacy symbolic network for literacy.

This system is based on a network of meanings, its semantic base (St. John & McClelland, 1990). The network permits readers to construct mental representations of texts (Kintsch, 1998). The units of meaning have phonological and orthographic 'addresses' (Stage, Abbott, Jenkins, & Berninger, 2003) that successful readers use rapidly automatically while reading to interpret texts. They can also extend their meaning networks and modify the symbolic system.

Acquisition of the literacy symbolic system involves the successful integration and automatization of several areas of knowledge. A noted above, one aspect is a linguistic competence; an individual's ability to comprehend and use vocabulary, comprehend various types of sentence propositions and links between them and to use word order or grammar. A second aspect is memory competence, indicated in the ability to retain ideas in verbal short-term working memory. A third is learning or generating the symbolic addresses or codes for written language; phonological and phonemic knowledge, orthographic processing, recalling rapidly the names and sounds of letter clusters and using analogy to learn new orthographic knowledge (Berninger, Abbott, Thomson and Raskind, 2001; Goswami, 2000; Thompson, Cottrell and Fletcher-Flinn, 1996; Wolf, Bowers, & Biddle, 2000).

Reading acquisition is affected when the construction of any of the aspects of the system is restricted. One might expect that reading disabilities have multiple causes. Earlier studies confirm this. Factor analytic procedures indicate the psycholinguistic and cognitive attributes associated with reading ability. Bell, McCallum and Cox (2003), for example, identified a range of cognitive influences on the reading achievement of elementary and middle school children; auditory processing and phonological awareness skills, short-term auditory and visual memory, rapid automatized naming and visual processing speed.

Cluster analysis procedures showed how the factors co-occurred in individuals who had reading disabilities. Morris et al. (1998), for example, identified seven subtypes of dyslexia based on combinations of phonology, short term visual memory, naming rate, spatial reasoning, word meaning, and oral language: (a) a phonology, visual memory and rate deficit; (b) a phonology, visual memory and spatial deficit; (c) a phonology, visual memory and lexical deficit; (d) a phonology and rate deficit; (e) a rate deficit; (f) a global language deficit; and (g) a global deficit. Those students whose reading disability was most severe had naming speed, phonological and visual memory deficits.

The double-deficit hypothesis of dyslexia provides one conceptual framework for integrating the multiple causes of dyslexia. Readers who display reading disability may have deficits in either or both of processing phonological information and naming speed (Wolf, 1999; Wolf et al., 2002). These deficits lead to three subtypes of dyslexia that differ in the fluency with which readers read letters, words and connected text (Katzir, Kim, Wolf, Morris & Lovett, 2008). For isolated word reading, deficits in both areas lead to lower accuracy than deficits in one area, which did not differ. For prose reading, those with phonological difficulties read more accurately than other groups, who again did not differ. For comprehension, the naming and phonological deficit groups didn't differ and achieved at a higher level than the double deficit group.

This hypothesis proposes that phonological processing and naming speed operate as independent knowledge sources in accounting for developmental dyslexia. This proposal is not supported universally. A review of the evidence by Vukovic and Siegel (2006), for example, raises two challenging findings; for some readers with dyslexia at least, naming speed is (1) correlated with phonological processing and (2) does not influence reading outcomes. Support for the double-deficit hypothesis depends on the age or developmental level of the students, the information they are required to name (for example, pictures versus letters and digits) and characteristics of the dyslexia and how it is identified. The evidence does not support a persistent core deficit in naming speed for readers with dyslexia but suggest instead that its influence diminishes with development.

Deficits in these two areas of knowledge are not restricted to dyslexic readers. Badian (1997) compared the double-deficit profiles of dyslexic and 'garden-variety' poor readers who had comparatively low verbal reasoning scores for primary school age. In terms of the components for the dyslexic group, 50 % had a phonological, naming and orthographic deficit, 18 % had a phonological processing and naming speed deficit, 18 % had a naming speed and orthographic skill deficit. In the garden-variety group 23 % had a phonological processing and naming speed deficit and 18 % had a naming speed deficit.

The review by Vukovic and Siegel leads one to ask more general questions about the examination of multiple knowledge profiles that contribute to reading disability. It is possible that the knowledge profiles that characterize early literacy acquisition are not relevant to literacy learning in the middle or later years of primary education. For successful reading development, rapid naming or phonological awareness, for example, may be necessary in the early phases but gradually lose their significance as the reader constructs a more complex literacy symbolic system.

In other words, the knowledge profiles may have a developmentally restricted influence for successful reading. Using knowledge profiles that characterize middle literacy acquisition to infer the causal knowledge profiles of early literacy acquisition may be inappropriate. While rapid naming processes, for example, may not influence the reading performance of older successful readers, it would be incorrect to conclude that it did not necessarily influence their earlier reading performance and assist them to build a symbolic network that would scaffold later reading ability.

As noted earlier, the integration of multiple areas of knowledge, including a particular level of phonemic knowledge and rapid naming, may be necessary for constructing the complex symbolic system that underpins literacy knowledge. The aspects of knowledge need to be available at the appropriate time for integration. Delayed acquisition of one or more aspects, for example, in rapid naming ability at the time of integration, may lead to a literacy learning difficulty. Later acquisition may not contribute to progress along a successful literacy learning trajectory.

The identification of multiple causes of literacy learning difficulties have direct implications for both the diagnosis of reading disabilities and for implementing the most effective intervention programs. Some students may develop more slowly the aspects of knowledge necessary for an effective literacy symbolic network while others may not develop specific areas of knowledge at all. Differentiated teaching procedures may be necessary to build the alternative knowledge clusters that young readers bring to the literacy education context (Velluntino et al, 1996; Francis et al, 1996).

An aim of the present research is to identify the literacy learning characteristics of early primary students who were at risk of not benefiting from conventional early literacy education programs and to infer the characteristics of their literacy symbolic knowledge. Unlike most earlier studies, it examines evidence of multiple causes of reading disability at a single year level, rather than across a range of grade levels. It assumes that the characteristics of at risk students in the middle years of schooling may differ from those of students in the earliest phases of literacy learning.

Identifying the risk factors for reading disability in the emergent phase of literacy learning has several advantages. Early accurate diagnosis of disabilities is more likely to lead to effective teaching and hence to reducing the likelihood of future difficulties.

A second aim of the present study is to examine the possibility of multiple causes of reading disabilities when young readers are learning to comprehend prose. Emergent readers build their literacy symbolic networks in part by reading appropriate prose. The earlier studies of subtypes of reading disabilities have tended to focus on dyslexia, that is, difficulties associated with individual word reading accuracy. Evidence of multiple influences on accuracy and comprehension for connected prose have received less attention. It is possible that the types of knowledge necessary for text comprehension differ from those needed for word reading accuracy. The present study examines the possibility that reading comprehension difficulties can be explained in terms of multiple causes.

Method

Participants. The study involved 314 first grade students, of whom 154 had prose reading accuracy scores on the Neale Analysis of Reading Ability (Neale, 1999) below the 25th percentile. All had a verbal reasoning scaled score of above 84 on the Kaufman Brief Intelligence Test K-BIT (Kaufman & Kaufman, 1990). The students attended 21 primary schools in metropolitan Melbourne. Teachers from the 21 schools selected potential participants. The psychometric assessments described below determined the students' involvement in the present study.

The students whose reading accuracy scores were below the 25th percentile are described as 'at risk' as literacy learners and those above the 24th percentile are described as 'good progress' literacy learners. This criterion has been used to identify students who may in the future be at risk in terms of successful literacy learning (Manis, Doi & Bhadha, 2000).

In terms of the demographic features of the two groups, the at risk group ((N =154) was comprised as follows; 16 % came from families that received the Educational Maintenance Allowance, 15 % came from Non-English Speaking background families, there was 1 Koorie student and 1 Integration student. The good progress group (N =160) did not have any students who met these criteria.

Materials. The participants' performance was assessed on a range of reading, psycholinguistic and cognitive tasks. Several of these are standardized tasks in published assessment scales. They provide comparative normative description of performance and are not described in detail here. The tasks used are as follows:

1. Prose reading was assessed using the Neale Analysis of Reading Ability (Neale, 1999). This scale was used to assess students' prose reading accuracy and comprehension. Prose reading raw scores on the Neale Analysis of Reading Ability were converted to standard scores for analysis.

2. Receptive vocabulary was assessed using the Peabody Picture Vocabulary Test (Third Edition).

3. Receptive syntactic awareness was assessed using the Sentence Structure (Receptive) Test on the CELF 3 Clinical Evaluation of Language Fundamentals (Semel, Wiig & Second, 1995).

4. Expressive syntax was assessed using the Word Structure (Expressive) Test on the CELF 3 Clinical Evaluation of Language Fundamentals.

5. Imitative short term memory for the verbatim retention of sentences of increasing length in short term auditory sequential memory CELF 3 Recalling Sentences (Expressive) Test on the CELF 3 Clinical Evaluation of Language Fundamentals. on the CELF 3 Clinical Evaluation of Language Fundamentals (Semel, Wiig & Second, 1995).

6. Phonological and phonemic knowledge was assessed using the Sutherland Phonological Awareness Test (Neilson, 2003). The following tasks were used: rhyme production, onset identification, first phone identification, segmentation 1, blending, initial phoneme deletion and segmentation 2.

7. Verbal and nonverbal reasoning were assessed using the K-BIT Expressive Vocabulary and K-BIT Matrices scales (Kaufman & Kaufman, 1990).

8. Listening comprehension narrative memory was assessed by having participants listen to a story about a familiar event of 248 words and answer questions about it. Their story schema was assessed by having them retell the story. Their responses were assessed in terms of reference to the setting, the initiating event, internal responses, attempt, consequence and ending.

9. Immediate short term auditory sequential memory for words was assessed by having the participants listen to a list of names of familiar items and recall them in any order. Delayed recall was assessed following an interpolated activity of approximately five minutes.

10. Short term visual sequential memory for objects was assessed by showing the participants pictures of a set of familiar items one a time and then having them select, from a set of pictures that included these items, the ones they had see. They did this by pointing to the items in the collection in the order in which they recalled seeing them.

11. Short term visual sequential memory for letters was assessed by showing the participants pictures of a set of letters one a time in a format similar to that used for short term visual sequential memory for objects.

12. Phonological short term memory was assessed by having each participant hear a sequence of pseudo words of increasing length, for example, *fim, lut, grum, stig*. The participant's task was to repeat what was heard.

13. Verbal analogies was assessed by saying simple incomplete analogies about familiar events such as "*a cow moos, a dog….*" and asking the participant to complete it.

14. Learning an orthographic code was assessed by showing the participant a set of six simple visual symbols, each matched with a unique lower case letter placed above it. They were also shown a scrambled set of the simple visual symbols and asked to write, under each item in this set, its matching letter. They had 60 seconds to do this task.

15. Visual symbolic processing was assessed by showing the participant a lower case letter and a sequence of four lower case letters. The participant decided, as quickly as possible, whether the letter was included in the string of four letters. The participant had 60 seconds to complete as many strings as possible.

16. Orthographic processing for letter clusters was assessed by showing the participant a set of five vertically arranged letters or letter clusters, one of which was repeated. The letter clusters were pseudo onsets, rimes or words of up to five letters long. The student's task was to circle the repeated letter or letter cluster. The student was told to do as many tasks as possible and had 60 seconds for this.

17. Rapid automatized naming speed for letters and digits was assessed by showing the participant a string of ten lower case letters or digits. The student's task was to say the name or each letter or digit as rapidly as possible. The time taken to name each string correctly was recorded. Only responses in which all letters or numbers were named correctly were included in the analysis.

18. Matching Spoken and Written Words was assessed by showing the participant a set of 20 items that were either a letter or a pseudo word letter cluster of up to five letters. The participant heard a sound pattern and identified the matching written item.

19. Letter Sound Decoding reading written pseudo words of increasing length was assessed by assessing the participant's ability to read a set of 20 items that were pseudo words of up to five letters.

Procedures. Qualified primary school teachers were trained to administer the various tasks in the participants' schools over several sessions. The training included explicit task moderation procedures. Participant selection decisions and result interpretations were made by the writer with other members of the research team.

Results

Two measures of prose reading were used in this investigation; reading accuracy and reading comprehension. The 'at risk' and 'good progress' participant groups were comprised as follows. An at risk group, the students whose score was in the lowest 25 percentile range, was identified for each measure of prose reading. In all, 154 students had at least one measure in this range; 128 had both scores in the range, seven had a comprehension percentile score greater than 25 and 19 had an accuracy percentile score greater than 25. The good progress group was the complement in each case.

Comparison of the cognitive and psycholinguistic performance by the at risk and good progress readers. In the initial analysis, mean performance of the at risk and good progress readers on the various measures of psycholinguistic and cognitive performance was compared. The at risk group achieved at a lower mean level than the good progress readers on all tasks ($p < .01$).

The extent to which each area of psycholinguistic and cognitive performance varied with prose reading standard score (comprehension and accuracy) was examined by computing the relevant correlations for the at risk and good progress groups for each measure of prose reading. These data (Spearman's rho, 2-tailed) are shown in Table 1.

Table 1: The extent of association (Spearman's rho, 2-tailed) between the areas of psycholinguistic and cognitive knowledge and prose reading standard scores (comprehension and accuracy).

Area of psycholinguistic and cognitive knowledge	Accuracy		Comprehension	
	At risk readers N=135	Average readers N=179	At risk readers N=147	Average readers N=167
Phonemic, phonological processing				
Phonemic awareness total	.45**	.043	.32**	.11
Phonemic segmenting total	.40**	.043	.28**	.12
Oral language				
Listening Comprehension	.03	.07	.059	.25**
Story Schema	.11	-.03	.075	.14
Recalling Sentences	.20*	.35**	.20**	.39**
Expressive syntax	.30**	.27**	.22**	.29**
Receptive Syntactic Awareness	.19*	.14	.22**	.21**
Receptive Vocabulary	.09	.26**	.18*	.37**
Visual symbolic, orthographic processing				
Visual Memory Objects	.21**	.02	.16*	.07
Visual Memory Letters	.29**	.28**	.13	.21**
Learning an Orthographic Code	.28**	.14	.38**	.13
Visual Symbolic Processing		.28*	.15	.29**
Orthographic Processing of Words	.23**	.28**	.25**	.27**
Rapid Automatic Naming (RAN)				
RAN Letters Time for correct response	-.34** (N=84)	-.26** (N=119)	-.42** (N=106)	-.27** (N=107)
RAN Digits Time for correct response	-.17 (N=92)	-.23* (N=108)	-.25** (N=100)	-.19 (N=98)
Short term memory				
short term memory for words immediate	.12	.11	-.00	.14
short term memory for words delay	.10	.19**	.02	.12
PSTM TS	.17	.12	.19*	.05

** for correlations significant at the .01 level (2-tailed)
* for correlations significant at the .05 level (2-tailed).

The magnitude of the correlations are generally low, suggesting a small effect size. Given this, these data provide an indication of possibly different influences on the reading performance for the good progress and at risk readers:

1. phonemic, phonological processing influenced both accuracy and comprehension performance for the at risk but not for the good progress readers.

2. aspects of oral language knowledge influenced reading outcomes differentially; imitative and expressive syntax had a broad effect for both groups while vocabulary and listening had a greater affect comprehension for good progress readers, particularly for

comprehension. This suggests a semantic processing effect for the good progress readers. They are consistent with the prediction that the good progress readers, having automatized aspects of word level processing, are more able to draw on their semantic knowledge.

3. visual memory and visual symbolic processing influenced reading outcomes differentially. At risk reading outcomes correlated with visual memory for objects and the ability to learning an orthographic code while the orthographic processing of words correlated with both measures of reading for both groups of readers.

4. rapid automatic naming ability for letter influenced the reading accuracy of both groups and the comprehension of the good progress readers. The rapid naming of digits influenced the reading accuracy only of at risk readers.

5. short term memory for words and sound patterns tended not to influence reading outcomes.

These associations suggest that the prose reading performance of the at risk and good progress readers are influenced differently by the aspects of cognitive and psycholinguistic knowledge. These influences on early learning to read were examined further by using data reduction procedures.

The cognitive and psycholinguistic patterns associated with at risk reading. The second step involved subjecting the summary psycholinguistic and cognitive variables to principal component analysis using SPSSx version 16. The variables used were letter sound decoding total score, matching spoken and written words total score, phonological awareness segmentation 2 total, phonological awareness segmentation 1 total, phonological awareness final phoneme identification, phonological awareness blending total, phonological awareness initial phoneme deletion, phonological awareness rhyme production, receptive vocabulary standard score, recalling sentences standard score, verbal analogies, receptive syntactic awareness standard score, expressive syntax standard score, phonological short term memory total score, short term memory for words delay trial, short term memory for words immediate standard score, RAN digits time corrected, RAN letters time corrected, orthographic processing of words total score, visual symbolic processing, learning an orthographic code, listening comprehension , listening comprehension story schema, visual memory for letters total score, verbal reasoning standard score, nonverbal reasoning standard score and visual memory for objects total score.

Prior to implementing PCA, the suitability of this analysis was assessed. Inspection of the correlation matrix indicated that several of the variables had an association exceeding 0.3. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy was 0.79 and Bartlett's Test of Sphericity (Approx. Chi-Square, df = 300) = 1018.553 ($p < .001$).

A varimax rotation method was used as the extraction method with Kaiser normalization. Rotation converged in 27 iterations. It indicated eight components with eigenvalues greater than 1. These accounted for 27 %, 10 %, 8%, 7%, 6% and 5 % of the variance respectively, that is, 64% of the variance in total. The rotated solution showed six-component, with most variables loading on one. The variables loading on each component are shown in Table 2.

Table 2 : The rotated solution for the 'at risk' readers.

	1	2	3	4	5	6	7	8
Letter Sound Decoding	.733							
Phonological Awareness Segmentation 2	.732							
Matching Spoken and Written Words	.704							
Phonological Awareness Segmentation 1	.689							
Phonological Awareness Final Phoneme Identification	.678							
Phonological Awareness Blending	.673							
Phonological Awareness Initial Phoneme Deletion	.642							
Phonological Awareness Rhyme Production	.563							
Verbal Analogies		.694						
Receptive Vocabulary		.637						
Recalling Sentences		.600					.414	
Expressive Syntax		.555						
Verbal Reasoning		.549	-.486					
Receptive Syntactic Awareness		.442			.437			
RAN letters time corrected			-.754					
RAN digits time corrected			-.752					
Listening Comprehension				.880				
Listening Comprehension Story Schema				.851				
Orthographic Processing of Words					.751			
Learning an Orthographic Code					.523			
Visual Symbolic Processing			.482		.485			
Short Term Memory for Words Immediate						.808		
Short Term Memory for Words Delay Trial						.792		
Non-Verbal Reasoning							.734	
Phonological Short Term Memory							.610	
Visual Memory Letters								.694
Visual Memory Objects								.656

The eight components were named as follows:

1. Component 1 included the tasks assessing phonological and phonemic knowledge and its use in word reading;

2. Component 2 included the variables for psycholinguistic knowledge and verbal reasoning ;

3. Component 3 included the variables for rapid automatized naming of both alphanumeric symbols (letters and digits) and words retained in short term memory;

4. Component 4 covered the variables for listening comprehension;

5. Component 5 included the variables for orthographic processing of alphanumeric symbolism;

6. Component 6 included the retention of words in short term memory;

7. Component 7 included two variables that had little in common; non-verbal reasoning and phonological short term memory and

8. Component 8 covered the two variables associated with the brief retention of visually presented letters and pictures of real life items.

The extent to which each of these components was implicated in prose reading was examined by computing the association between the Neale accuracy and comprehension scores and each component. The component scores were estimated using the regression procedure in SPSSx 16. The correlation coefficients (Spearman correlation, 2-tailed, N = 107) for each measure of prose reading and each component is shown in Table

Table 3 : The association (Spearman correlation, 2-tailed, N = 107) between the Neale accuracy and comprehension scores and each component.

component	Accuracy	Comprehension
phonological and phonemic knowledge	.465**	.340**
psycholinguistic knowledge and verbal reasoning	.170	.142
rapid automatized naming	.270**	.007
listening comprehension	.096	.106
orthographic processing	.031	.242*
retention of words in short term memory	.046	-.086
component 7	.050	.020
brief retention of visual information	.094	.196*

** for correlations significant at the .01 level (2-tailed)
* for correlations significant at the .05 level (2-tailed).

These data show that three of the components are associated with reading performance by the at risk first graders; the phonological and phonemic knowledge component was associated with both accuracy and comprehension, the rapid automatized naming component with accuracy, the orthographic processing component with comprehension and the brief retention of visual information.

This trend was supported ($p < .01$) was supported by comparing the mean accuracy and comprehension across the five levels of performance for each component using Oneway ANOVA procedures. The exception was the trend across the brief retention of visual information; the trend here did not achieve significance for any of the prose reading conditions. Subsequent analyses examine the implications of components 1, 3 and 4 for the reading disabled students.

The extent of correlation between the three components was examined by computing the extent of association between the corresponding component scores (Spearman's rho, N = 152). No correlation coefficient achieved a magnitude exceeding 0.09. These data indicate that the three components were not associated at the .05 level of significance. It is reasonable to conclude, therefore, that each component contributes comparatively independently to the measures of prose reading.

Further evidence that each factor contributes comparatively independently to each measure of prose reading was indicated in the distributions of the early readers across the three factors. The distribution of the scores for each component were grouped into five categories. This permitted an analysis of the number of categories of one factor associated with the one category of a second factor.

The distribution (percentage) of the categories of rapid automatized naming (component 3) and orthographic processing (component 5) for each category of phonological and phonemic knowledge (component 1) are shown in Table 4.

Table 4 : The distribution (%) of the categories of rapid automatized naming (component 3) and orthographic processing (component 5) for each category of phonological and phonemic knowledge (component 1).

group	component	component 1 groups				
		1	2	3	4	5
1	3	24	24	19	10	23
	5	29	14	15	14	28
2	3	14	19	10	19	38
	5	9	19	19	24	29
3	3	14	14	29	33	10
	5	15	14	14	19	38
4	3	30	20	10	20	20
	5	25	30	15	25	5
5	3	14	24	33	19	10
	5	24	24	29	19	4

These data show, for example, that the at risk students in the lowest phonological and phonemic category were not necessarily in the lowest category for rapid automatized naming or for orthographic processing. Instead, these students were distributed over the various categories of performance for each of the other component. A corresponding pattern was observed for the at risk students in the highest phonological and phonemic category. The Pearson Chi-Square tests for each of the two distributions with the phonological and phonemic component scores support this interpretation; it did not achieve significance.

These trends illustrate how the various components operate independently in the early phases of the acquisition of reading by students who have reading disabilities. They suggest the need for early diagnostic and intervention programmes to target each component.

The extent to which the emergent readers is this study display the patterns associated with the double-deficit hypothesis of dyslexia (Katzir, Kim, Wolf, Morris & Lovett, 2008) was examined by using the component scores to identify three sub-groups within the at–risk group; one with comparative phonological difficulties, one with comparative rapid naming difficulties and one with difficulties in both areas. The prose reading means for these three sub-groups were compared using Oneway ANOVA. They are shown in Table 6.

Table 6 : The prose reading means and standard deviations for the sub-groups with (1) comparative phonological difficulties, (2) comparative rapid naming difficulties and (3) difficulties in both areas.

aspect of prose reading	low in phonological (n=24)		low in RAN (n=25)		low in both (n=17)	
	Mean	St d.	Mean	St d.	Mean	St d.
Accuracy	4.67	3.608	8.44	4.059	5.00	4.345
Comprehension	1.17	1.465	2.24	1.615	1.65	1.656

The three groups differed in both accuracy and comprehension $(F2 , 63) = 5.37$, $p < .01$ and $(F2 , 63) = 2.97$, $p < .05$ respectively). In terms of both accuracy and comprehension, the ‘ low in RAN’ sub-group had the higher mean and the other two groups, who did not differ (Scheffe multiple comparisons). These patterns differ from those reported by Katzir, Kim, Wolf, Morris & Lovett (2008).

The data also suggest a re-examination the extent to which the dual deficit model describes prose reading difficulty. The three independent components identified here suggest that in addition to phonological and naming speed deficits (Katzir, Kim, Wolf, Morris & Lovett, 2008; Wolf et al., 2002), it may necessary to include orthographic processing.

The cognitive and psycholinguistic patterns associated with good progress reading. To facilitate the further evaluation of the data for the at risk cohort, a corresponding principal components analysis was completed for the good progress readers. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy for this analysis.

A varimax rotation method was used as the extraction method with Kaiser normalization. Rotation converged in 9 iterations. It indicated eight components with eigenvalues greater than 1. These accounted for 16 %, 11 %, 10%, 7%, 7%, 6 %, 6 % and 5 % of the variance respectively, that is, 68% of the variance in total. The rotated solution showed eight components, with most variables loading on one. The variables loading on each component are shown in Table 7.

Table 7 : The rotated solution for the 'good progress' readers.

variable /task	1	2	3	4	5	6	7	8
Verbal Reasoning	.754							
Receptive Vocabulary	.687							
Receptive Syntactic Awareness	.672							
Non-Verbal Reasoning	.659							
Expressive Syntax	.445							
Verbal Analogies	.436							
Letter Sound Decoding		.730						
Phonological Short Term Memory		.708						
Phonological Awareness Initial Phoneme Deletion		.689						
Imitative Syntax		.608						
Matching Spoken and Written Words		.517						
Listening Comprehension			.907					
Listening Comprehension Story Schema			.901					
RAN letters time corrected (>2 errors =0)				.866				
RAN digits time corrected (>2 errors =0)				.865				
Orthographic Processing of Words					.806			
Learning an Orthographic Code					.762			
Visual Symbolic Processing				-.404	.518			
Visual Memory Letters								
Short Term Memory for Words Immediate						.881		
Short Term Memory for Words Delay Trial						.819		
Phonological Awareness Segmentation 2							.822	
Phonological Awareness Segmentation 1							.794	
Phonological Awareness Blending							.481	
Phonological Awareness Final Phoneme Identification								.820
Phonological Awareness Rhyme Production								.627

The eight factors were named as follows:

1. Component 1 draws together tasks to do with verbal reasoning about various aspects of text; receptive vocabulary, receptive syntactic awareness, verbal analogies, verbal and nonverbal reasoning and expressive syntax. It suggests a semantic processing aspect. It matches the psycholinguistic knowledge and verbal reasoning (component 2) in the solution for the at risk cohort and is referred to as the psycholinguistic knowledge and verbal reasoning component.

2. Component 2 includes a number of tasks that involve either retaining and vocalizing sound patterns in a particular order or sequence (vocalizing a sequence of letters, a sequence of words and pseudo words) or retaining a spoken sequence of sounds (matching sounds with letters). These lead to word recognition. This component is not matched in the at risk solution and is referred to as the retention and word reading component.

3. Component 3 matches the listening comprehension in the at risk solution

4. Component 4 matches the rapid automatized naming component in the at risk solution but is more focused in that it applies only to visually presented symbolic information.

5. Component 5 matches the orthographic processing component noted for the at risk readers.

6. Component 6 covers the retention of words in short term memory and matches component 6 for the at risk readers.

7. Component 7 matches part of the phonological and phonemic component (component1) for at risk readers. The variables drawn together in this component are those used to read words.

8. Component 8 matches the second part of the phonological and phonemic component for at risk readers. The phonological variables covered here drawn together in this component are those usually acquired earliest, the implicit phonological awareness phase.

The extent to which each of these factors was associated with trends in prose reading was examined by computing the correlation between the Neale accuracy, comprehension and rate scores and each of the factors. The factor scores were estimated using the regression procedure in SPSSx 16. The correlation coefficients (Spearman correlation, 2-tailed, N = 112) for each measure of prose reading and each of the factors is shown in Table 8.

Table 8 : The association (Spearman correlation, 2-tailed, N = 107) between the Neale accuracy and comprehension scores and each component.

component	Accuracy	Comprehension
verbal reasoning	.309**	.329**
retain and say sound patterns	.345**	.273**
listening comprehension	-.098	.107
rapid automatized naming	-.251**	-.221*
orthographic processing	.284**	.291**
short term retention of words	.005	.039
phonological knowledge to read words	.108	.035
implicit phonological awareness	.054	-.012

** for correlations significant at the .01 level (2-tailed)
* for correlations significant at the .05 level (2-tailed).

These data show that four of the components are associated with reading performance by the good progress first graders; verbal reasoning (component 1), retaining and saying sound patterns (component 2), rapid automatized naming (component 4) and orthographic processing (component 5).

The extent of correlation between the four components was examined by computing the extent of association between the corresponding component scores (Spearman's rho, N = 107). No correlation coefficient achieved a magnitude exceeding 0.04. These data indicate that the four components were not associated at the .05 level of significance. They contribute independently to the variance for each aspect of prose reading.

Comparison of the component solutions for the at risk and good progress readers. The principal component analysis for the good progress readers provides a perspective for analyzing the performance patterns of the at risk readers. As noted, the component solutions for the two groups are similar in several ways. Both groups, for example, showed a listening comprehension component and a short term memory for words component, neither of which correlated with prose reading ability. These are obviously aspects of learning at this age and, given that the two groups differ in their ability in these areas ($p < .01$), they may be prerequisite to learning to be literate.

One difference is in phonological and phonemic knowledge. For the at risk readers, all measures of phonological and phonemic knowledge loaded on a single factor. The good progress readers on the other hand, showed differentiated phonological and phonemic performance, with the measures loading on at least two components. Those acquired early developmentally (the implicit phonological awareness variables) loaded onto Component 8 while those acquired later developmentally and used to read words (phonemic segmentation and blending) loaded onto a separate component (Component 7).

A second difference related to the extent to which the phonological and phonemic knowledge component/s were associated with reading achievement. For the at risk readers, the phonological and phonemic knowledge component was associated with prose comprehension and reading accuracy ($p < .001$). A similar association did not emerge for the good progress readers.

Component 2 for the good progress readers most closely matched this association. This component drew together several tasks that involved retaining and vocalizing sound patterns in a particular order and using these to read words and pseudo words. It suggests that the good progress readers were synthesizing their phonological and letter cluster knowledge in an explicit sequential way. It accounts for approximately 12 % of the variance in reading accuracy and 8 % of the variance in comprehension. The at risk group did not show this component.

A third difference between the two groups emerged in the extent to which they used their psycholinguistic knowledge when reading. Both groups displayed a psycholinguistic knowledge and verbal reasoning component. It influenced prose reading, however, only for the good progress readers ($p < .001$). This is consistent with the possibility that the students who have reading disabilities are less likely to use these aspects of their knowledge when they read. Aspects of this component include using word meanings, using synonyms, using the grammar of sentences to link ideas and making verbal analogies. This study shows that while the students who have reading disabilities have access to this knowledge cluster, each aspect is less developed than that of their good progress readers, and that they are less likely to use this knowledge when they read.

A fourth difference relates to the influence of rapid automatized naming on reading performance. Both groups showed this component, but its nature differed, suggesting a developmental trend. For the at risk readers, performance on the picture naming and visual symbolic processing tasks loaded with the rapid digit and letter naming tasks. For the good progress readers, on the other hand, only performance on the rapid digit and letter naming tasks loaded on the factor. This is consistent with the gradual differentiation of rapid naming processes. As such it provides indirect support for the perspective proposed by Vukovic and Siegel (2006). It is younger children who are more likely to show rapid naming effects for pictures as well as letters and digits.

A fifth difference relates to the influence of orthographic knowledge on prose reading. While an orthographic component emerged for both groups, its influence was more broad based and greater for the good progress readers. The data are consistent with the interpretation that while the at risk readers had begun to construct and to use this knowledge, they were not using it as effectively as their good progress reading peers.

A sixth difference between the two groups is the component associated with the brief retention of visual information. While a decision was made not to continue to examine it as a main predictive component in the present study, its influence is worthy of a passing mention. This component was correlated with prose reading comprehension for the at risk students but not for the good progress readers. Visual retention strategies usually involve representing information by naming individual items and noting perceptual features. The results suggest that the at risk students are more likely to use these strategies when reading prose in order to comprehend it. It is consistent with not using more analytic-semantic processes.

Discussion

Differences in the literacy symbolic networks for the at risk and good progress readers. The principal component analysis for the two groups of readers and the patterns of correlation with prose reading provide a basis for inferring the characteristics of literacy symbolic networks constructed by the at risk readers. First, the observed similarities of the two component solutions suggest that both groups are drawing on a broadly matching knowledge base. Both groups, for example, showed a listening comprehension component and a short term memory for words component, neither of which correlated with prose reading ability. These are obviously aspects of learning at this age and, given that the two groups differ in their ability in these areas ($p < .01$), they may be prerequisite to learning to be literate. In other words, the symbolic networks of both groups probably already had these areas of knowledge in place and the good progress readers had each represented at a higher level.

It is the differences that assist us to understand how and why the learning disabilities arise in terms of the literacy symbolic knowledge, their nature and how they can be remediated. The difference between the two groups in the structure of the phonological and phonemic knowledge component relates to the phonological aspect of the symbolic network. The data for the good progress readers suggest differentiated phonological and phonemic knowledge, with a clear separation between those aspects of phonological knowledge acquired early and those acquired later developmentally. In other words, the good progress readers showed a clear developmental trajectory in phonological and phonemic knowledge. Their literacy symbolic networks are informed by phonological and phonemic knowledge that is available for generating new sound patterns to match the unfamiliar words encountered in texts. The observation that neither of these components was associated with either reading comprehension or accuracy suggests that, in their literacy symbolic systems, their phonological and phonemic knowledge are already sufficiently well developed to scaffold or underpin reading the prose on which they were assessed. It is consistent with these students drawing on this knowledge relatively automatically.

The emergence of Component 2 for the good progress readers suggests the specific linking of letter cluster and phonological knowledge in the literacy symbolic network. A matching component did not emerge in the at risk group. Further, while the two phonological components were not associated with reading performance for the good progress readers, performance on this component was strongly correlated. For the good progress readers, higher prose reading accuracy and comprehension were associated with higher performance here. This suggests that the good progress readers were synthesizing their phonological and letter cluster knowledge in an sequential way and were using it explicitly and strategically.

The at risk group did not show these performance patterns. First, all measures of phonological and phonemic knowledge loaded on a single factor. The literacy symbolic networks for some members of this group did not have access to the clearly differentiated knowledge shown by the good progress readers. As well, performance on this component was associated with both prose reading comprehension and accuracy ($p < .001$). For these at risk readers, their phonological knowledge had not achieved the level of automaticcompetence achieved by their good progress reading peers.

The emergence of the verbal reasoning component as an influence on prose reading only for the good progress readers ($p < .001$) suggests another difference between the symbolic literacy networks for the two groups of readers. As noted, both groups displayed a psycholinguistic knowledge and verbal reasoning component. This knowledge was, therefore, potentially available as a semantic factor to the symbolic networks for both groups. The difference in the association patterns suggests that it is better established and linked in the literacy networks of the good progress readers. Some members of the at risk group were less likely to draw on their knowledge of vocabulary, sentence meanings and sentence structure as they read.

A key aspect of the successful use of any symbolic system is the capacity to recall efficiently the names and meanings of the symbols used. While both groups of readers showed the influence of rapid automatized naming on their reading performance, they differed in the range of items to which it applied. The good progress readers differed only in the time they took to retrieve the names of digits and letters; they did not differ in their speed of naming pictures and visual geometric shapes. Some of the at risk readers, on the other hand, showed the rapid naming influence across the range of attributes. This suggests that the at risk readers are less able to use key aspects of their literacy symbolic system as efficiently as their good progress readers; they recall the names and sounds of letters and the names of items less automatically. As noted, their use is consistent with a developmental trend.

A difference between the two groups of readers is in the use of orthographic knowledge during prose reading. The data are consistent with the claim that while both groups of readers have begun to construct an orthographic component as part of their literacy symbolic knowledge, the good progress readers have achieved this much more effectively. Some of the at risk readers had difficulty in assembling this aspect of their literacy symbolic networks.

In summary, the literacy symbolic networks for the at risk and good progress readers differ more in the developmental status of the multiple areas of knowledge that it comprises and in their integration and use of this knowledge. There are emergent readers in the at risk group who show a lack of differentiated phonological and phonemic knowledge, those who showed less facility with acquiring orthographic knowledge and those who are less able to recall efficiently the names and meanings of items and those who have less well developed psycholinguistic and verbal reasoning knowledge.

The present findings support the claim that for students in the early phases of literacy learning, reading disabilities are heterogeneous, with multiple potential causes. They show that while the capacity to process sounds patterns in words and to construct and use phonological representations is one aspect, a second is the capacity to generate and use orthographic symbolic knowledge and a third is to retrieve and to link these aspects of knowledge. The assumption that young readers acquire spontaneously and incidentally the capacity to generate orthographic knowledge is not appropriate to those who have reading disabilities.

Comparison of the component solutions for the good progress and at risk readers, particularly in terms of the task loadings, suggest that for each component, the at risk readers are developmentally immature. The various components of the good progress readers are more differentiated and 'tuned' to literacy learning than the matching components displayed by their at risk peers. When the components are integrated their approach to literacy learning may appear to be a deviation from typical development rather than delayed.

Developmental trends in the literacy symbolic networks for prose readers by younger and older reading disabled students. The three areas of knowledge that influence the prose reading ability of the young at risk readers are consistent with those noted in earlier studies for older students, for example, those of Berninger, et al., (2001) and Bell, et al., (2003). The three factors identified by Berninger, et al match the orthographic, phonological and rapid naming aspects of knowledge noted in this study. They differed, however, in the aspects of prose reading they affected. For the students in the present study, the orthographic component affected only reading comprehension, while the rapid naming influenced only reading accuracy.

Similarly, the phonological awareness skills, short-term visual memory and rapid automatized naming noted by Bell, et al. match those identified here. In the study by Berninger, et al, that involved students from grades 1 to 6, the orthographic factor influenced accuracy and rate while naming affected reading rate only. These differences are consistent with a developmental trend. In both studies the phonological aspect influenced all aspects of reading.

Developmental trends can also be examined in terms of their support for the Dual Deficit Hypothesis. While the double-deficit hypothesis was developed to explain dyslexia, as noted earlier it has been used to examine multiple influences on prose reading. The young at risk children in the present study did not show the influences on prose reading reported for older reading disabled children (Katzir, Kim, Wolf, Morris & Lovett, 2008). For the older children, RAN had a greater influence on reading accuracy and the double deficit on comprehension. In the younger children in present study, the group lower on the phonological component and the group lower in both achieved at a lower level. These findings are consistent with a developmental trend in the symbolic literacy network; phonological competence and RAN are gradually consolidated and it is their integration that continues to restrict reading growth.

The data also suggest, however, that it is insufficient to examine an integration of only phonological knowledge and RAN, particularly when analyzing prose reading. The dual deficit description may be incomplete for prose reading difficulty. The three independent components identified here add to an increasing body of evidence to suggest that, in addition to phonological and naming speed deficits, it may necessary to include orthographic processing. It is certainly warranted from the perspective of a complete symbolic literacy network.

Implications for teaching. The findings of the study have several implications for reading intervention at the emergent reading phase. Assessment and diagnostic procedures need to take account of the multiple areas of knowledge that can contribute to reading difficulty.

The data for the good progress readers suggest that a successful 'literacy learning readiness' profile would describe, for emergent readers, their knowledge in the areas of

1. verbal reasoning,
2. retaining and saying sound patterns,
3. rapid automatized naming and
4. orthographic processing.

As noted, each component is characterized by a developmental trend in the knowledge it represents. The behaviours associated with each are indicated by the tasks and skills that were linked with each component. This profile can be used to locate the students in a grade 1 cohort and to identify those who display a larger number of 'at risk' characteristics.

It is expected that the literacy learning readiness profiles of students who are at risk of reading disability will vary, to reflect the multiple aspects of knowledge that synthesize into a capacity to learn to read successfully. Some may have comparatively low performance in a verbal reasoning, some in retaining and saying sound patterns, some in rapid automatized naming and some in orthographic processing. Some will show this low performance in more than one area.

A child's literacy learning readiness' profile will provide the basis for implementing the most effective teaching program. Each of the four areas above merits a teaching regime. An example of this approach to intervention for three of these areas of knowledge is described in Munro (2006). It is possible that a group of students who display the same low level of reading achievement may need quite different interventions, depending on the aspects of knowledge that are comparatively less well developed.

The findings suggest as well that the good progress readers have achieved automaticity in relevant areas of knowledge. They have also made strategic links between aspects of knowledge. The at risk children were less likely to have made these links. The intervention may need to include teaching at develops the areas of knowledge in these ways.

Summary

The present study used the notion of a literacy symbolic network to focus on the multiple aspects of knowledge that young readers synthesize in order to read and comprehend prose. It has shown how at risk emergent readers differ from their good progress peers in these aspects of knowledge. It draws attention to the concept of a literacy learning readiness profile that can assist professionals working with these students to identify their individual literacy learning characteristics and to design effective intervention.

It is likely in the future that the multiple areas of knowledge that underpin effective text comprehension will attract more interest and that, with the continued development of technology-assisted teaching, instructional regimes that target the specific learning profiles of students will be implemented.

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