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Contents

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Editorial Comment

Angela J Fawcett

It is a very great pleasure to launch this new journal, the Asia Pacific Journal of Developmental Differences, which is published by the Dyslexia Association of Singapore. Our research into the market for this journal identified a very real need for a high quality journal that could cover a broad range of developmental differences in the area.

The Asia Pacific Journal of Developmental Differences is unique in addressing a range of special educational needs including dyslexia, autism, dyspraxia, dyscalculia, and ADHD in the Asian Pacific context. The journal covers theory into practice and will provide a showcase for research in the Asia Pacific region as well as highlighting research areas which have implications for further research within Asia and beyond.

Based on many years experience as editor-in-chief of Dyslexia: an International Journal of Research and Practice, I have been well placed to recruit a strong editorial board. I have been heartened by the very positive response from our editorial board towards the need for a new journal, and by the submission of a broad range of high quality articles for review. The articles included here in this first issue have been selected based on the following criteria. The articles all successfully contribute to the further understanding of developmental differences as well as applications and implications in educational, social and cultural environments. The papers include sound research methods, and good interpretation and validity of results, presented in the appropriate academic context. They are all original papers that have not been published in other journals or publications.

Over the last 18 months, as Academic Director for the Dyslexia Association of Singapore, I have reached a clear understanding of the difficulties we face in helping children who are bi-lingual to reach their potential. I see the introduction of this journal as an important step in broadening knowledge and understanding in the area, not least of the overlaps between many of the conditions that we are working with.

My own research, with my colleague Professor Rod Nicolson from Sheffield has for example produced a new theory of procedural learning deficits in dyslexia, (Nicolson and Fawcett, 2007) which can provide a framework for understanding the strengths as well as the weaknesses in children with a range of developmental differences. However, the journal is not constrained by adherence to any specific

theoretical stance, but is open to good quality submissions from all theoretical persuasions. There is rich potential here to work together towards a better future for our children, sharing knowledge and expertise to move the area forward in seeking effective and cost-effective solutions to aid our work. A key issue here to my mind is the availability of information on progress in the field, and it is planned that this journal will be instrumental in spreading awareness of research and practice that has proved effective in other contexts, in addition to progress in Asia.

The brief of the journal is to include research papers based on sound methodology, reviews of developments in the area, and case studies of theory into practice. We will publish controlled studies, longitudinal studies, and simple accounts of approaches that have worked in the Asia Pacific context. There is also a strong commitment to recognising the need for greater understanding for children with developmental differences, and this will be a theme running through the journal, starting from this first issue. This journal should be a showcase for publishing material from well established and highly regarded authors right through to post-doctoral students and teachers who have never prepared an article before. The editor is committed to developing the skills of her contributors, where appropriate, to facilitate the growth of a new generation of researchers and practitioners. The peer review process will ensure that all the material published is worthy of publication in this journal.

In this first issue, I have grouped the articles in terms of their methodology and approach, starting with controlled research studies that report statistics. Following a section on human aspects of dyslexia, a series of case studies and reviews are presented. The first two articles in the research studies are drawn from an Asian background, with contributions from Professor Connie Ho and colleagues, and Professor Ken Poon and colleagues. In the Ho paper, 'Pragmatic Skills in Chinese Dyslexic Children: Evidence from a Parental Checklist', Lam and Ho compare children with autism and dyslexia with controls. Interestingly they show that the dyslexic group fall between the autistic and the controls in their understanding of language, reflecting a mild pragmatic impairment that has not previously been identified in this group. The Lee and Poon article addresses a key area for language learning in Asia, 'The impact of teaching methods on learning Chinese characters in bi-lingual children with dyslexia'. The authors show that the Stroke method is more effective than Hanyu Pinyin in teaching children Chinese characters in primary 1.

The article from James Chapman and Bill Tunmer from New Zealand' The Literacy performance of Young adults who had reading difficulties in school' reviews the impact of intervention approaches on literacy in young adults, noting that skills remain low in this group. The authors conclude that schemes advocated by the New Zealand government have been largely unsuccessful in improving literacy in this group, and commend the use of phonological interventions in line with those used in the UK, the US and Singapore. This section is followed by

two articles on early screening and intervention; the first article by See and Koay is entitled 'The Identification of dyslexia in pre-school children in a Multi-Lingual society'. This article reviews the impact of screening on the identification of children at risk for dyslexia within the Dyslexia Association of Singapore, using the Dyslexia Early screening test (Nicolson and Fawcett, 2004).

The second article on this topic by Fawcett and colleagues 'Sustained benefits of a multi-skill intervention on pre-school children at risk for reading difficulties' considers the value of screening and intervention with children in nursery and demonstrates lasting impact for a short-term intervention at age 4 years in comparison with controls.

These articles precede an article from Tom West, 'Amazing shortcomings, Amazing strengths'. Tom is one of the major players in the USA in recognising the importance of strengths in dyslexia, and presents an inspiring piece in line with the emerging Positive dyslexia movement. This seeks to explore the strengths of dyslexia, rather than focusing on weaknesses in literacy, encouraging adults to follow their strengths and arguing for the important role of dyslexic adults in a creative society.

The final section of the journal includes a case study; from Tim Bunn of the Dyslexia Association of Singapore, on the understanding and management of Maths difficulties in Singapore 'Mathematical difficulties in Singapore: a case study approach'. The article acknowledges controversies in the area and discusses how children with 'dyscalculia' or maths difficulties present and can be helped.

The calibre of these articles is exceptional and fulfils our criteria for a combination of theoretical rigor and applied value.

We are confident that we can maintain this standard of submission for the next issue that will be published in July 2014. In this issue, we will be calling for papers for the International conference on Developmental Differences, which is planned for 2015. We also plan to make articles available on the new DAS website for early view, following acceptance for issue 2 onwards.

We look forward to receiving your submissions and to continue to produce an outstanding journal that addresses issues of prime importance for the Asia Pacific region.

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Asia Pacific Journal of Developmental Differences
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Pragmatic Skills in Chinese Dyslexic Children: Evidence from a Parental Checklist

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Individuals with deficits in pragmatic skills, the skills of applying and interpreting language appropriately in its occurring context, may lead to reduced communication ability that affects social interactions. The present study aimed at examining whether children with dyslexia had pragmatic deficits and what their specific language profile was as compared with normally-developing children and those with autistic spectrum disorder (ASD). Sixty-eight participants of Grades 3 to 6 were recruited from five mainstream schools in Hong Kong. They were divided into the Dyslexia group (N=22), the ASD group (N=22) and the Control group (N=24) matched on age, IQ, and SES. The Children Communication Checklist-2 (CCC-2, Bishop, 2003), a parental checklist, was used to collect information regarding the language and communication abilities of these children. Results showed that the Chinese dyslexic children had reduced pragmatic skills compared to normally-developing children. These dyslexic children were relatively weak in structural language skills and reduced general communication scores that were comparable to children with ASD, but they were normal in social relationships and interests. These results provided new insights for investigating communication abilities of the dyslexic population and implied a possible need for remediation of this population in the domain of language use.

Keywords: pragmatic skills, dyslexia, Chinese, Children Communication Checklist-2 (CCC-2)

Pragmatic Skills

Form, content and use are three intertwined domains of language. Pragmatics, also known as the use of language, is one of the important domains that affects the success or failure of our communication. Pragmatic skills are the language abilities to apply and interpret language appropriately in its occurring context (Bishop, 1997). These skills are involved in comprehension and production of tailored forms and meanings of language to fulfill different goals and intention in varying social demands and situations (Dockrell & McShane, 1993; Landa, 2000). This flexibility enhances the effective use of

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language to communicate with different contents and meanings, through various forms like nonverbal communication, spoken and written language.

In written communication, meaning could always go beyond what is literally written. Inferential meanings consist of a considerable portion in different texts, articles and books. They could not be overlooked or else the communication would not be complete (Caccamise & Snyder, 2005; Westby, 2004). For example, Chinese idioms are commonly used expressions observed in both daily and formal communication. They carry both literal and hidden meanings which come from historical and cultural allusions. Interpretations of these idioms require linguistic, pragmatic and world knowledge. Mastering the literal and figurative meaning of them is an expected age-appropriate language task for primary school children (Tsou, et al., 2006). Individuals with lower pragmatic skills were usually having poorer comprehension and usage of these idioms that contain indirect meanings (Kerbel & Grunwell, 1998). Textual comprehension is another area that also requires one's sophisticated pragmatic skills. It does not only demand readers' linguistic knowledge and world knowledge to decode words, to understand syntactic structures and to identify schemata and scripts. Successful and thorough comprehension also requires one to have sufficient pragmatic knowledge. Pragmatic skills are necessary in scenarios that require readers to detect hidden logical relationships, to make coherent understanding and to identify writers' or characters' illocutionary force from sentences and passages (Buck, 2001; Garnham, 1989; Tsou et al., 2006). Individuals with better pragmatic skills could obtain more information from contexts in written texts to enhance their inferential reasoning from words and sentences to master the overall meaning while those with pragmatic difficulties may be impaired in these situations (Leu, DeGroff & Simons, 1986).

Pragmatic Deficits

Despite the great importance of pragmatics in one's oral and written language, not every individual possesses age-appropriate skills in this language domain (Griffiths, 2007). The presence of some developmental disorders may hinder the normal development of one's pragmatic skills to a significant extent and this may lead to pragmatic deficits and communication impairments.

For instance, individuals with autism spectrum disorders (ASD) are characterized with pragmatic deficits. ASD is a collective term referring to diagnoses of autism, autistic features, Asperger's syndrome and related pervasive developmental disorders. Individuals with ASD have delayed development in structural language aspects like syntactic, morphological and phonological skills as well as in language use. Difficulties in pragmatics are disproportionately more prominent among different language domains in children with ASD and such difficulties may persist throughout their lifespan (Geurts & Embrechts, 2008).

Besides ASD, developmental disorders like attention deficit hyperactivity disorder

(ADHD) and specific language impairment (SLI) may also be associated with pragmatic difficulties, although impaired use of language was not an essential diagnostic criterion of these disorders. For example, individuals with SLI have delayed or distorted spoken language development that is not explained by other conditions like mental retardation, hearing or physical impairment etc. These individuals have heterogeneous language profiles, which could have comprehension or expression difficulties either on structural language components or pragmatic components, and sometimes they could have difficulties on both domains (Geurts & Embrechts, 2008).

Individuals with pragmatic deficits could have reduced communication ability while facing different social or situational contexts or have distorted and unexpected language performance during specific context (Martin & McDonald, 2003). Reduced pragmatic skills may be manifested as limited communicative functions, unable to comprehend verbal or nonverbal contextual cues, insufficient response to others' communication, interaction and conversation. Distorted pragmatic skills may be manifested as inappropriate initiation or termination of conversation, stereotypic production or over-literal interpretation and production.

Developmental Dyslexia

Developmental dyslexia (DD) is a learning disorder recognized by unexpected discrepancy between their intelligence and literacy attainment. This mismatch is manifested with literacy impairment, where proficiencies of reading and writing are affected (Snowling, 2000; Vellutino, 1979). Generally speaking, around 2 to 4 percent of school populations may have severe DD, while a further 6 percent may have mild to moderate reading difficulties (e.g., Badian, 1994; Miles & Miles, 1999). Individuals with DD often show impairments in word-recognition, spelling, reading comprehension and writing (Bruck, 1990; Miles, 1993). Phonological deficits (Snowling & Nation, 1997; Van Daal & Van der Leij, 1999), rapid naming deficits, and other cognitive deficits (Badian, 1997; Willows, Corcos & Kershner, 1993; Wolf and Bowers, 1999) have been found to be some cognitive causes for DD. (Ho et al., 2002; Stanovich, & Siegel, 1994; Watson & Willows, 1993; Willows, 1991).

However, pragmatics, as an important aspect of language, remains unexplored in the dyslexic population until recent years. Riddick, Farmer and Sterling (1997) reported in their survey results that dyslexic children showed difficulties such as incoherent and disorganized speech content, inappropriate topic initiation and difficulty of their communication partners to make sense of their utterances. Similarly, Cooke (2001) reported communication difficulties of dyslexics such as failure to understand jokes and idioms, failure to identify minute social cues and reduced processing of communication content. These difficulties could be categorized under pragmatic competence. These communication problems seem to persist in dyslexic adults. Griffiths (2007) investigated pragmatic skills of well-compensated dyslexic adults using self reported

questionnaire and selected subtests from Dyslexia Adult Screening Test (DAST, Fawcett & Nicolson, 1998) and Right Hemisphere Language Battery (RHLB, Bryan, 1995). Results across different measurements suggested that dyslexic adults were showing significantly reduced pragmatic skills compared to those without dyslexia. The results demonstrated that individuals with dyslexia may have possible correlation with impairments in the use of language, namely the domain of pragmatics.

Measuring Pragmatic Skills

To investigate pragmatic competence of an individual, reliable and valid tools are needed. Structural language abilities such as speech, semantics or syntax have a variety of standardized measurements to evaluate one's performance on these areas. However, tests for pragmatic competence to date are limited, and these tests often lack sensitivity or are limited to superficial aspects only (Glumbić & Brojčin, 2012). This posed difficulties for researchers and clinicians to make accurate judgment on an individual's pragmatic competence. Pragmatic skills are difficult to assess for two reasons (Bishop & Baird, 2001).

First, pragmatic skills are highly context-dependent. Pragmatic skills could only be observed in specific social or situational contexts. The occurrence of targeted behaviors is relatively indefinite compared to other language domains. In the aspects of structural language, researchers or clinicians could create situations to elicit certain skills of the respondents (e.g., divergent naming of different categories of objects to assess semantic knowledge, reading words containing specific speech sounds to assess phonological skills). Regarding pragmatic skills, this is relatively less feasible. When certain pragmatic skills are elicited in artificial test settings, they may reflect respondents' capability in this specific communicative environment. If complete and accurate measurement of an individual's pragmatic skills is expected, measurement across a wide range of communicative contexts will be needed. This makes the assessment time-consuming or even not practical (Norbury et al., 2004).

Second, atypical or deviated communicative behaviors indicating possible pragmatic deficits are usually infrequent in their occurrences. Comparatively, deficits in structural language aspects (e.g., syntactic structure errors in expressive language impairment, initial-consonant-deletion in speech disorder) are more consistent and frequent. These errors could be observed by researchers or clinicians during assessment or even naturalistic observation. However, pragmatic errors (e.g., over-literal interpretation of others' expression) occur in specific contexts and therefore are relatively rare. Researchers or clinicians' observation may not coincide with these scenarios so the deficit will be overlooked.

Based on the above considerations, Bishop devised a checklist to evaluate children's pragmatic skills in 1998, the Children's Communication Checklist (CCC). The checklist was revised by Bishop in 2003 into a second version (CCC-2). She presented prominent features of strengths and weaknesses in

different communication areas (including structural and pragmatic language) in a systematic format with objective and concrete ways of ratings. The checklist was designed to be used by people that could observe children's communicative behavior across a wide range of social contexts for a prolonged period, such as parents, teachers or significant others of the individual. This was to overcome the previously mentioned limitations of clinical assessment and naturalistic observation made by researchers or clinicians and to provide more representative profiles on children's everyday communication. The checklist was standardized on children in UK to provide reliable and accurate measurement of children's communication skills.

Acceptable validity, reliability and internal consistency of the checklist were reported (Norbury, et al, 2004; Geutrs, 2007). The checklist was able to distinguish between individuals with or without pragmatic disorders. The initial study of CCC (Bishop & Baird, 2001) showed different clinical groups scored differently in the pragmatic composite. ASD group received lowest rating, SLI group followed and control group was rated highest. CCC-2 could depict a wide range of language functions and could be used as a more general screening tool for communication impairments. Since their publication, CCC and CCC-2 gained popularity and were used widely across the globe to describe different communication profiles and distinguish communication deficits in children with ASD, SLI and other disorders (Bishop, et al., 2011; Bishop & McDonald, 2009; Ferguson et al., 2011; Whitehouse, Barry & Bishop, 2008).

Aims of the Present Study

The present study investigated the pragmatic skills of Chinese dyslexic children. There were two research aims. First, it examined whether Chinese dyslexic children have pragmatic deficits with the use of CCC-2. It was hypothesized that this group of children would have impairment in this language domain. Second, it studied the specific language profile of children with dyslexia, comparing their CCC-2 results with normally-developing children and children with ASD. By comparing with normal controls and pragmatically impaired ASD children, the relative pragmatic competence of this population could be understood. It was hypothesized that dyslexic children would have poorer pragmatic skills compared to normally-developing children. Also, the severity of the pragmatic impairment would be lower compared to ASD children. It was hypothesized that dyslexic children would also have structural language difficulties but have normal social relationship and interests.

This study hopes to bring new insights about the communication skills of the dyslexic population. Besides language content and form, which were studied more in-depth by other previous studies, the current study will start to build a more complete picture about the language profile of the dyslexic population.

Method

Participants

Sixty-eight Chinese children and their

Table 1—Background information of the participants

	Groups						Statistics
	Dyslexic (n=22)		ASD (n=22)		Control (n=24)		
	Mean	SD	Mean	SD	Mean	SD	
Age (Months)	126.1	14.4	130.6	16.4	122.0	14.3	$F(2,65)$=1.875, p=.162, partial $\eta 2$=.055
IQ score	93.6	6.7	99.3	12.5	99.0	9.9	$F(2,65)$=2.324, p=.106, partial $\eta 2$=.067
Socio-Economic-Status	Percentage (%)		Percentage (%)		Percentage (%)		
Parents' Education Level (1/2/3/4/5) *	0/22.7/54.5/22.7/0		4.5/18.2/54.5/18.2/4.5		8.3/29.2/25.0/33.3/4.2		X^2(8, n= 68)= 7.562 p=.477
Parents' Occupation (1/2/3/4/5/6) #	36.4/50.0/4.5/0/4.5/4.5		27.3/31.8/4.5/0/27.3/9.1		37.5/25.0/12.5/0/25.0/0		X^2(8, n= 68)= 9.692, p=.287
Family Monthly Income (1/2/3/4/5) @	0/4.5/36.4/13.6/4.5		0/0/42.9/19.0/38.1		12.5/8.3/16.7/12.5/50.0		X^2(8, n= 67)= 10.543, p=.229

Notes: Parent education level * 1. Primary or below /2. Junior secondary /3.Senior secondary /4.Post-secondary /5.Master degree or above
Parents' Occupation # 1. Managers/ Administrators / Professionals /2. Clerks / Service workers / Shop sales workers 3. Craft / Plant and machine operators and assemblers /4. Elementary occupations /5. Unemployed 6. Others
Family Monthly Income @ 1. $6000 or below /2. $6001 to $10,000 /3. $10,001 to $20,000 /4. $20,001 to $30,000 /5. $30,001 or above

parents were recruited from Grades 3 to 6 in five mainstream primary schools in Hong Kong. They were categorized into three different groups: (1) the Dyslexia group (n=22); (2) the Autistic Spectrum Disorder (ASD) group (n=22) and (3) the Control group (n=24). Children in the dyslexic group had school record of special educational needs (SEN) of dyslexia, diagnosed by professional educational or clinical psychologists. Children in the ASD group had school SEN records of ASD, including diagnoses of autism, autistic features and Asperger's syndrome, diagnosed by pediatricians or psychiatrists. Children in the Control group had no SEN records of any developmental disorders. Children in the three groups were matched on age, IQ, and SES (see Table 1). All the participants were reported to use Cantonese Chinese as their first language or one of the most commonly used languages at home.

Materials and Procedures

Children's Communication Checklist-2 (CCC-2; Bishop, 2003), Raven's Standard Progressive Matrices (Raven, 1981) and a demographic information questionnaire were used in this study to assess children's communication skills, estimate their general intellectual ability and collect demographic information on these children and their families respectively.

Children's Communication Checklist-2.
CCC-2 is a checklist developed to be completed by individuals that were familiar with the children, such as parents, caregivers or teachers. Seventy items were included in the checklist, divided into 10 subscales with 7 items each. These subscales aimed to investigate the strength and weakness of different areas regarding children's language, communication and social aspects. They are (A) speech; (B) syntax; (C) semantics; (D) coherence; (E) inappropriate initiation; (F) stereotyped language; (G) use of context; (H) nonverbal communication; (I) social relationships; and (J) interests. The first four subscales (A-D) measure competence of structural language aspects of children. They identify deficits on children's phonology and articulation, syntactic ability, vocabulary and discourse skills respectively. The next four subscales (E-H) tap into children's pragmatic skills. Common pragmatic deficits are categorized into these four areas. Inappropriate initiation subscale (E) measures impairments involved in conversational topics such as repetitive initiations, failure to commence topics with mutual interests and talking too much. Stereotyped language subscale (F) describes atypical and unusual expressions such as overuse of bizarre, overly precise or specific learned phrases. Use of context subscale (G) investigates the adequate comprehension and expression related to social rules such as the use and understanding of politeness, humor and irony. Nonverbal communication subscale (H) targets on the appropriate understanding and utilizing of nonverbal communication like facial expressions, bodily movements and gestures. The remaining two subscales (I-J) measure characteristics commonly observed in children with ASD. They look into children's relationship with other individuals and identify any rigid, repetitive or atypical interests (Glumbić &

Brojčin, 2012; Volden & Phillips, 2010).

Each item in the CCC-2 consists of a statement describing certain behavior. Among the seven items in each subscale (A-J), five of them measure weaknesses and two of them measure strengths in those communication areas. They add up to 50 negative items and 20 positive items in total. For example, item 34 "takes in just one or two words in a sentence, and so often misinterprets what has been said", it described a behavior of weakness in the subscale (G), use of context; item 62 "conversation with him/her can be enjoyable and interesting", it described a behavior of strength in the subscale (E), inappropriate initiation. The 50 items regarding weaknesses were randomized in order and presented first. Respondents, which were the participants' parents in this study, were required to rate their children's performance according to their daily observation. The ratings were evaluated in a 4-point scale (0 – less than once a week or never; 1 – at least once a week; 2 – once or twice a week; 3 – more than twice a week or always). The 20 items regarding ability were randomized in order and presented next. Respondents were required to rate children's performance in another 4-point scale (0 – children yet to achieve; 3 – children have been able to achieve). The formats of rating scales were set to be definite and objective. The randomization of item order was expected to minimize response bias. A consistency check was established to ensure the responses to positive and negative items were consistent. This monitored and improved the validity of the checklist.

The ratings obtained from the checklist were then computed into scaled scores of each of the ten subscales with a mean of 10 and standard deviation of 3. The abovementioned scoring procedures were based on the original UK norm provided by the publisher. Besides subscale scores, four composite scores could be calculated from the scaled scores to further analyze some characteristics of the tested children's communication skills. Structural language composite (SLC) estimates their structural language skills. It is calculated by the summation of scaled scores of subscales A to D. Pragmatic language composite (PLC) estimates their pragmatic language skills. It is calculated by the summation of scaled scores of subscales E to H. The general communication composite (GCC) estimates the overall communication skills. It is calculated by the summation of scaled scores of subscale A to H. The social interaction deviance composite (SIDC) estimates the discrepancy between structural language aspects and pragmatic skills. It is calculated by the subtraction of the sum of subscale E-H from the sum of subscale A-D. Positive SIDC indicates structural language outperformed pragmatic language, while negative SIDC indicates pragmatic language outperformed structural language. Scaled scores of the ten subscale and the composite scores help to provide an overview of language profile of the tested children (Geurts & Embrechts, 2008).

A Chinese version of the CCC-2 was used to assess the Chinese children in the present study. It was translated from the original English version with slight cultural adaptations, mainly on the examples

provided. The license to use the Chinese checklist for research purpose was obtained from the publisher.

Raven's Standard Progressive Matrices. It is a standardized test devised by Raven in 1981 to estimate children's nonverbal intelligence. Sixty items were printed in a booklet, divided into 5 sets with 12 items each. Each item consisted of either a single visual matrice or a set of visual matrices, where part of it or one of the set was missing respectively. Participants were required to select the appropriate missing piece from the given list of six to eight choices to complete the matrice. Total raw scores were added up and converted into intelligence quotient (IQ) equivalents, with a mean of 100 and standard deviation of 15. Local norms established by the Hong Kong Education Department (Raven, 1986) were used in the scoring procedures of the current study.

Demographic Information Questionnaire. A questionnaire was designed by the authors to collect demographic information of students and the SES of their families. It was designed to be completed by parents of the participating children. Respondents were required to provide children's gender, date of birth, prior diagnoses and treatment of developmental disorders to the best of their knowledge. This information was cross-checked with schools' records. They were required to state their relationship with the children and the most commonly used language at home. The information was used to confirm the validity of the observation and exclude confounding caused by differences in language background. SES was measured from the given information about parents' educational level, parents' occupation and family monthly income. This information was used to exclude possible effect of family SES on children's language performance.

Results

Strengths and weaknesses of children's communicative abilities were measured using the Children's Communication Checklist-2 (CCC-2; Bishop, 2003). Subscale scores provided indication of children's communication ability in specific areas. Composite scores aggregated various subscales to identify deficits in certain language domains.

Scaled scores of the ten subscales and composite scores of CCC-2 of the three groups were summarized in Table 2. The subscale scores were compared among the three groups using univariate ANOVA. Results indicated that all but one (A. Speech) subscale scores had significant group differences (all ps < .05). Post-hoc analyses were performed to make multiple pairwise comparisons between subscale scores among the three groups using Tukey test. Results suggested that the Dyslexia group had significantly lower scores than the Control group in subscales E (inappropriate initiation), $p<.05$, and subscale G (use of context), $p<.05$. All subscale scores of the ASD group were significantly lower than those of the Control group (all ps < .05). Compared with the ASD group, the Dyslexia group had significantly higher scores in subscales I (social relationship) ($p<.05$).

Univariate ANOVA was also used to

Table 2—Mean Scores, Standard Deviations, and Group Comparisons of the Children's Communication Checklist Scores

	Groups						Statistics					
	Dyslexic (D)		ASD (A)		Control (C)		ANOVA			Post-hoc Analysis (*p* value)		
	Mean	SD	Mean	SD	Mean	SD	*F*(2,65)	*p*	partial *η2*	D vs C[@]	A vs C[@]	D vs A[@]
Subscales Score												
A. Speech	5.8	3.5	4.6	3.1	7.0	3.1	3.092	0.052	0.087	D <C	A <C *	D >A
B. Syntax	2.8	3.0	2.3	4.1	5.0	3.9	3.684	0.031*	0.102	D <C	A <C *	D >A
C. Semantic	5.8	2.8	4.8	3.2	7.7	3.5	4.982	0.010*	0.133	D <C	A <C**	D >A
D. Coherence	4.4	3.4	2.9	2.0	6.4	3.6	7.385	0.001**	0.185	D <C	A <C**	D >A
E. Inappropriate initiation	6.0	2.6	4.6	1.6	7.8	2.6	10.911	<0.001**	0.251	D <C *	A <C**	D >A
F. Stereotyped language	4.1	2.8	2.7	2.0	5.8	2.9	8.038	0.001**	0.198	D <C	A <C**	D >A
G. Use of context	4.4	2.6	2.7	3.0	6.6	3.4	9.369	<0.001**	0.224	D <C *	A <C**	D >A
H. Nonverbal communication	4.7	3.2	2.7	1.7	6.5	3.7	9.213	<0.001**	0.221	D <C	A <C**	D >A
I. Social relationship	5.1	3.5	2.7	2.4	5.8	3.7	5.673	0.005**	0.149	D <C	A <C *	D >A *
J. Interests	6.6	2.4	5.2	2.0	8.0	3.2	6.515	0.003**	0.167	D <C	A <C *	D >A
Composite Score												
SLC[#]	18.8	10.8	14.6	11.0	26.2	10.8	6.719	0.002**	0.171	D <C	A <C**	D >A
PLC[#]	19.2	9.4	12.7	6.9	26.6	10.1	14.004	<0.001**	0.301	D <C *	A <C**	D >A *
GCC[#]	38.0	19.4	27.3	16.6	52.8	19.1	11.136	<0.001**	0.255	D <C *	A <C**	D >A
SIDC[#]	-0.4	5.9	1.9	7.9	-0.5	8.4	0.726	0.488	0.022	D >C	A >C	D <A

Notes: * p<0.05 **p<0.01 [@]D vs C: Dyslexic vs Control A vs C: ASD vs Control D vs A: Dyslexic vs ASD

[#]SLC = Structural language composite(A+B+C+D) [#]PLC = pragmatic language composite (E+F+G+H)

[#]GCC = general communication composite (A+B+C+D+ E+F+G+H) [#]SIDC =social interaction deviance composite (A+B+C+D- E-F-G-H)

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compare composite scores of the three groups. Results indicated that significant group differences were observed in all but one (SIDC) composite scores (all ps < .01). Post-hoc analyses using the Tukey test showed that the Dyslexia group had SLC scores not statistically different from the Control group or the ASD group. The Dyslexia group had intermediate PLC scores among the three groups, which was significantly lower than that of the Control group, but significantly higher than that of ASD group (all ps < .05). The Dyslexia group had significantly lower GCC score compared to that of the Control group (p<.05) but comparable to that of the ASD group. The ASD group had significantly lower SLC, PLC and GCC scores compared to those of the Control group (all ps < .01).

Discussion

Pragmatic Skills of Dyslexic Children

Children's Communication Checklist-2 (CCC-2) results suggested that Chinese dyslexic children in this study had pragmatic deficits. Pragmatic language composite (PLC) score of the Dyslexia group was significantly lower than that of the Control group. The dyslexic children scored significantly lower in two out of the four pragmatic subscales, namely inappropriate initiation (E) and use of context (G), compared with normally-developing children of similar age, IQ, and SES. It appears that dyslexic children may have some genuine difficulties in developing adequate pragmatic skills.

The present CCC-2 results successfully distinguished between children with autistic spectrum disorder (ASD) and normally-developing children. The diagnostic label of ASD pointed to structural language impairment, pragmatic language impairment, atypical social relationship and interests. All these deficits were reflected from the comparison of the ten subscales between the ASD group and the Control group. All subscale scores and three composite scores, structural language composite (SLC), pragmatic language composite (PLC) and general communication composite (GCC), of the ASD group were significantly lower than those of the Control group. This result was consistent with those of previous studies (Bishop, 2003; Bishop & Baird 2001; Geurts et al. 2004, Norbury et al., 2004). CCC-2 was able to distinguish between children with and without communication impairments. This suggested that the parent-reported CCC-2 data in the current study were reliable and be able to identify deficits in different areas of communication skills in a Chinese population.

The present finding of children with dyslexia having signs of pragmatic deficits was consistent with those of past studies (Cooke, 2001; Griffiths, 2007; Hales, 1995; Riddick, Farmer & Sterling, 1997). Griffiths (2007) has suggested that pragmatic difficulties may be attributed to working memory deficit, affected speed of processing and reduced skill automatisation. Pragmatic skills are more complex than those in other language domains by nature. Besides mastering different levels of semantic and syntactic information, at the same time individuals need to process discourse information and contextual cues before accurately acquiring the complete pragmatic meaning of verbal or written information.

The greater demand on processing may overload one's limited working memory. This reduces the processing speed and skill automatisation of dyslexic individuals. Pragmatic deficits may also be a result of difficulties in the structural language skills in dyslexic children. Although the difference of SLC scores between the Dyslexia group and the Control group did not reach statistical significant level, dyslexic children displayed lower scores in structural language domains. This suggests that dyslexic children may have mild structural language difficulties which would affect their pragmatic competence. For instance, reduced ability in semantic and syntactic comprehension may affect the ability to comprehend details of a situation, making the use of contextual information less likely (Norbury et al., 2004). Future studies may examine the association between working memory, processing speed, structural language skills and pragmatic skills in children with dyslexia.

Language Profile of Children with Dyslexia vs. those with ASD

In the present study, CCC-2 is able to discriminate the language profile of children with dyslexia and those with ASD. Children with dyslexia demonstrate mild structural language difficulties, moderate pragmatic language deficits, general communication problems, but normal social relationships and interests. However, children with ASD show general communication problems with more severe pragmatic difficulties and social difficulties.

Past studies often failed to discriminate the language profiles of groups with different disorders (e.g., ASD, SLI, and ADHD), but dyslexia was not examined in these studies (Geurts & Embrechts, 2008; Norbury,et al., 2004). It appears that there may be more overlapping on the behavioural manifestations of these disorders but relatively less between dyslexia and ASD. In addition. past studies included participants of a wider age range (from 6 to 15 years old) while the present study examined children from 8 to 12 years old. Children of different ages have different demands in their communication. For instance, younger children may focus more on their structural language development while older ones more on social communication. Larger age range of the participants in other studies might have averaged out the effect of specific domains, making the composite scores less able to distinguish between different clinical groups.

Although the three groups had comparable social interaction deviance composite (SIDC), it was observed that the Dyslexia group and the Control group had negative SIDCs while the ASD group had a positive SIDC. This suggested that the dyslexic and normally-developing children in the present study had better pragmatic language skills than structural language skills, while the reverse was true for children with ASD. This is consistent with the explanation given by Geurts and Embrechts (2008). They have suggested that normally-developing children are able to communicate before learning to use language, so typically children have better pragmatic competence than structural language competence. A reversed pattern is often

observed in populations with severe pragmatic and social impairments like children with ASD.

Limitations and Suggestions for Future Research

The present study used information from parent-report to measure children's communication ability. Although strengths of using parent checklist were reported, Bishop and her colleagues suggested that CCC-2 could be used as complementing evidence rather than solely a diagnostic tool (Norbury, et al., 2004). Direct testing of pragmatic and other language skills may provide convergent evidence to the extent of pragmatic difficulties in dyslexic individuals. A longitudinal study also helps to clarify whether such pragmatic difficulties may persist over time.

Conclusion

In the present study, pragmatic skills of Chinese dyslexic children were investigated using a parental checklist, Children's Communication Checklist-2 (CCC-2). The present findings suggested that Chinese dyslexic children were less pragmatically competent when compared with normally-developing peers matched with age, intelligence and socio-economic-status (SES).

The CCC-2 results also show that Chinese dyslexic children have a specific language profile that is different from normally-developing children and children with autistic spectrum disorder (ASD). The present findings suggest that Chinese dyslexic children appear to have mild structural language difficulties, some pragmatic and general communication problems, but normal social relationships. Intervention to dyslexic children may therefore be focused not only on decoding and comprehension, but also on language use in social context. CCC-2 has also been demonstrated in this study to be a reliable tool to examine the language and communication skills of children with different developmental disorders in a Chinese population.

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The Impact of Teaching Methods on Learning of Chinese Characters among English-Chinese Bilingual Children with Dyslexia

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It is commonly thought that the use of Hanyu Pinyin (or 'Pinyin') can promote the learning of Chinese characters as it assists learners to pronounce new characters via a sub-lexical route (Dai & Lu, 1985; Huang & Hanley, 1997). However, there are also studies suggesting that presenting a Chinese character with its Pinyin depresses the rate at which the Chinese word can be learned (e.g., Solman & Adepoju, 1995; Solman & Chung, 1996). In view of this, this study aims to explore the impact of Pinyin during instruction on the acquisition of Chinese characters by Primary One students with dyslexia. Employing a single case alternating treatments design methodology, two girls and one boy diagnosed with developmental dyslexia were taught to read Chinese characters using two methods. The Pinyin method of teaching involves the pairing of the Chinese character printed on a card with its respective Pinyin transcription together with the teacher reading the word aloud. The Stroke method of teaching presents the order in which the strokes of the Chinese character are written in Pinyin. All three participants recognized more words when presented with the Stroke method across all sets of words. The implications of these findings to the nature of dyslexia and to the language learning of English-Chinese bilinguals with dyslexia are discussed.

Keywords: bilinguals, teaching Chinese, Pinyin, dyslexia

This study sought to examine the implications of teaching Hanyu Pinyin (which we will refer to as 'Pinyin') on the learning of Chinese Language among English-Chinese bilingual children with dyslexia in Singapore. Reading is the process of understanding speech in its written form, with the purpose of gaining access to meaning. It occupies an important role in education as learning to read is an essential skill that forms the basis for subsequent learning. However, unlike speech, reading is not naturally acquired and it often requires deliberate

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instruction. The ease within which single word (or morpheme) reading is learnt varies across languages. Languages with shallow orthographic depth (Frost, Katz, & Bentin, 1987), such as Spanish and Bahasa Melayu, are characterized by relatively straightforward grapheme-phoneme correspondence rules which are easier to acquire. In contrast, languages with deep orthographic depth such as Chinese have relatively little correspondence between the phoneme and its logographic representation. English is an alphabetic language with moderate orthographic depth as its alphabetic script allows the mapping of graphemes upon phonemes on some of its words but not others.

Learning to read in English and Chinese

In research literature studying the reading processes of bilingual children, the contrast between English and Chinese is interesting due to the contrast between the phonology, syntax, and orthography of the two languages (Gottardo, Chiappe, Yan, Siegel, & Gu, 2006). Although English is not considered an orthographically shallow language, the grapheme-phoneme correspondence is more direct than Chinese (e.g., Huang & Hanley, 1997). The reading of Chinese characters, in contrast, requires a memorization of the logographic representation of a word. For example, 'mother' is represented by the (simplified) Chinese character (or logograph) '妈'. To complement the learning of Chinese characters, Pinyin has been introduced in China and Singapore, so that the word can also be represented using alphabets as 'mā'. The phonology of some Chinese words can be guessed from its phonetic radical, for instance '马' (read Shu & Anderson, 1997 for a fuller discussion) as in the case of '骂' or 'mà' (meaning 'scold') or '马' or 'mǎ' (meaning 'horse'). The rationale for the introduction of Pinyin is based on the assumption that it can promote the learning of Chinese characters via a sub-lexical route requiring less assistance from the teacher (Dai & Lu, 1985; Huang & Hanley, 1997). However, there is also evidence suggesting that the teaching of Chinese vocabulary with a simultaneous presentation of Pinyin depresses the rate at which Chinese words can be learned (e.g., Solman & Adepoju, 1995; Solman & Chung, 1996). The question of how Chinese is best taught remains an issue that is being debated.

There is also evidence suggesting that the processes underlying learning to read in these languages differ. For instance, Huang and Hanley (1994) compared the way in which children learn to read English with how they learn to read Chinese and reported that children learning to read Chinese employed more visual skills than children learning to read English. Likewise, Chen and colleagues (2002) as well as that of Guo, Peng, and Liu (2005) provided evidence for a difference in processing routes in reading Chinese characters and Pinyin. This implies that the process of learning to read in English is different from that of learning to read Chinese characters. Likewise, the reading of Pinyin appears to employ a different set of phonological processes.

Developmental dyslexia in English and Chinese

There is an established understanding

that developmental dyslexia among alphabetic scripts is characterized by difficulties in learning to decode print (Vellutino, Fletcher, Snowling, & Scanlon, 2004). Vellutino and colleagues have argued that this phonological impairment is observed even among children with dyslexia who learn a non-alphabetic Chinese script. However, this view is by no means universal as there are also researchers who have proposed that orthographic (Ho, Chan, Lee, Tsang, & Luan, 2004) or morphological (Shu, McBride-Chang, Wu, & Liu, 2006) difficulties underlie Chinese dyslexia. Consequently, it is likely that children diagnosed with developmental dyslexia in one language can possibly present with different or no difficulties in another language (Bishop & Snowling, 2004). By applying the same logic, developmental dyslexia is expected to have a differential impact upon different written forms of the same language (e.g., Chinese written logographs and Pinyin). This situates Singapore as an ideal location for the examination of this issue.

Research objectives

All children in Singapore, with few exceptions, receive their education in the English medium and learn a second language, which is determined by their ethnic group. As ethnic Chinese children account for the largest group of children in the education system, Chinese is the most common second language learnt in Singapore. As part of the national curriculum for Chinese language, all children learn Pinyin during their first two years of primary education. However, this potentially poses a problem to students who have been diagnosed with developmental dyslexia in English language learning.

This study sought to understand the impact of Pinyin instruction alongside Chinese character instruction among Primary One students diagnosed with developmental dyslexia. It is hypothesized that the learning performance of Chinese characters with the co-presentation of Pinyin will be inferior to a method where only the characters are taught.

Method

Design

Single case design was adopted as this design involves repeated measures of participants' results allowing a visual examination of patterns in the dependent variable over time. This controls major threats to internal validity and enhances external validity (Martella, Nelson, & Marchand-Martella, 1999). The complex nature of bilingualism in Singapore makes the grouping of participants difficult as although practically all children in Singapore are bilingual, the relative strength in English and Chinese varies across each child. Given the nature of single case design where each child serves has his or her own control (Kennedy, 2005), it is particularly suited for heterogeneous populations such as the ones in this study. Likewise, the heterogeneity of dyslexia and its associated conditions make comparisons between individuals difficult. Furthermore, the exploratory nature of this study makes an approach examining fewer participants more appealing. More importantly, the alternating treatments

Table 1. Description of Study Participants

Participant	Gender	Chronological Age (in years)	Reading Age (in years)	Months of Remediation at DAS
Cara	Female	6	4	3
Lina	Female	7	5	7
Jack	Male	6	4	12

design allows the comparison of two teaching approaches in a small group of participants. These two treatments are alternated in rapid succession and changes are plotted on a graph to facilitate comparison (Cooper, Heron & Heward, 2007).

Participants

The three children who participated in this study are Cara, Lina, and Jack (two girls and one boy). They were attending Primary 1 at the point of recruitment and were recruited from the Dyslexia Association of Singapore (DAS) where they were receiving regular intervention (see Table 1). Although diagnostic information was not available, all children who receive support from DAS would have received a diagnosis of dyslexia from a psychologist. None were reported with any speech or hearing impairment or other diagnoses. All participants received between three to 12 months of intervention at DAS. They also come from English-speaking home environments and all were reported to be stronger in the use of English in comparison to Chinese. All participants learn Chinese as their mother tongue and none of them had previously learned foreign languages other than Chinese. In addition, Lina's mother provides extra time to support her in her learning of Chinese.

Materials

The teaching materials employed in this study were developed based on the following procedure. First, a corpus of 100

Character-Pinyin Cards (a) | Character-Stroke Cards (b) | Character-Recognition Cards (c)

Figure 1. Examples of Character Cards used for Teaching

Chinese characters with between 10 to 12 strokes per character ranging were selected from the Ministry of Education's primary school Chinese Language Syllabus Primary 1 and 2 wordlist. Following that, each participant was asked to recognize each of these characters. Only Chinese characters which were not recognized were adopted as teaching materials and the teaching materials were customized for each participant. The teaching materials for this study comprised three types of character cards (see Figure 1): (a) cards that presented the Chinese characters and their respective Pinyin transcription (Character Pinyin for Treatment A: Pinyin Condition), (b) Chinese characters and their corresponding sequence of strokes (Character Stroke for Treatment B: Stroke Condition), and (c) cards which were used to elicit recognition of characters (Character Recognition) that consisted of Chinese characters printed on the cards. The grade level and level of complexity varied between sessions but the stroke complexity was held constant between conditions. All character cards were plain white cards 15.2cm x 10.1cm in size.

Procedure

Approval to conduct this study was obtained from the university's Institutional Review Board before this study commenced. After parental consent and child assent was obtained, appointments were made for the participants to be assessed for their Chinese character recognition skills.

The Assessment *Phase* occurred only once before any teaching was conducted. During this phase, participants were tested on a corpus of Chinese characters drawn from the primary school curriculum. Each character was individually presented for five seconds or until a response was provided. Participants were asked to read them or to say "pass" if they did not know the answer. The teacher (the first author) did not provide any feedback on whether the words were read correctly during this phase. The correctly named characters read by the respective participants were excluded and the remaining characters were selected as teaching material for this study. Each participant hence had an individualized set of words that he or she learnt in this study.

This was followed by a *Teaching Phase* which consisted of eight teaching sessions. Each of the eight 20 minute teaching sessions employed either the Pinyin or the Stroke method. These teaching methods were alternated. Each teaching session introduced 10 new words to the participants. Different sets of words are used per session but word complexity (as measured by the number of strokes per character) was held consistent across respective teaching sessions. In the Pinyin Condition (Treatment A), each participant was presented with a character card of a Chinese character with its corresponding Pinyin printed under it. The teacher pointed to the Pinyin and said, "This character is pronounced as _____." The participant was asked to repeat the word, with the teacher underlining the Pinyin with her finger. A correct response was followed by the teacher saying, "Good". When the participant provided an incorrect response, the teacher would provide feedback saying, "Good try, but

the character is pronounced as _____". Once the participant was able to repeat the word, the teacher then pointed to the Chinese character saying, "the meaning of _____ is _____". The participant was then asked to repeat the meaning after the experimenter. This method of teaching was repeated for each of the ten characters. In the Stroke Condition (Treatment B), the teacher introduced each word saying "This character is pronounced as _____". As with the previous condition, the participant was asked to repeat it, with the teacher tracing the Chinese character with her finger. The feedback procedure for correct and incorrect responses is similar to that of the Pinyin Condition.

The *Posttest Phase* occurs after each teaching session. The participant was presented with each character was represented with a Character-Recognition card (see Figure 1) for up to ten seconds and was encouraged to read the character on the card. No feedback regarding their responses was given, but the participant was informed of the total number of words they recognized.

Results

The number of words identified correctly is presented on the y-axis for each respective participant in Figures 2 to 4. Each figure presents the learning accuracy for each of the four teaching sessions across the two conditions. The learning performance across each condition is presented as a line and a linear trend is also presented in the figures.

Visual analyses of Figures 2 to 4 reveal several trends. First participants consistently learn more words under the Stroke condition. Next, the trend line for the Stroke method is consistently positive

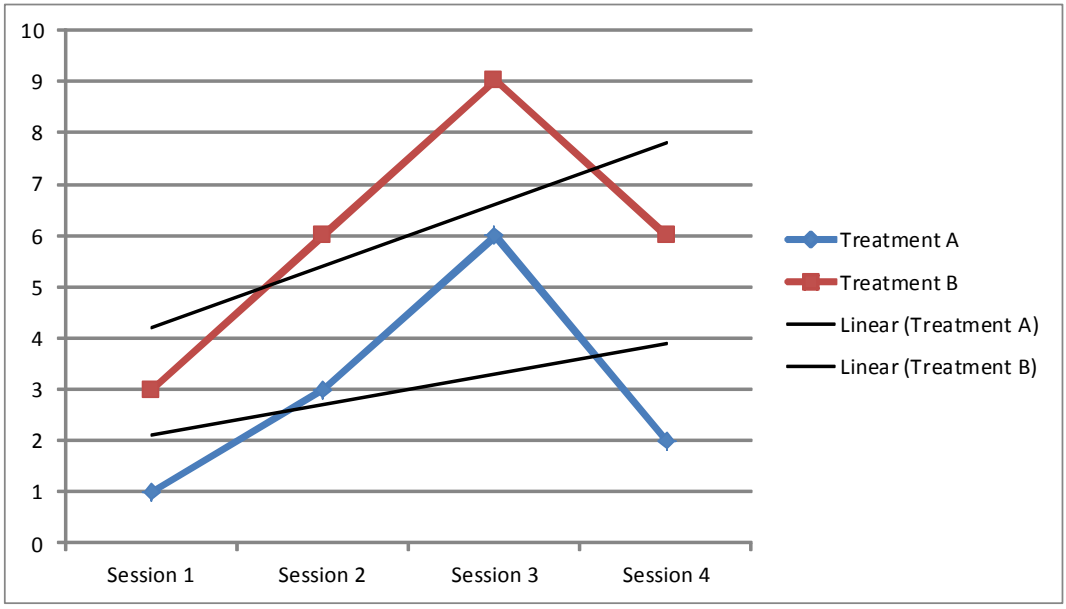

Figure 2. Graphic Representation of Cara's Word Recognition Under Each Condition

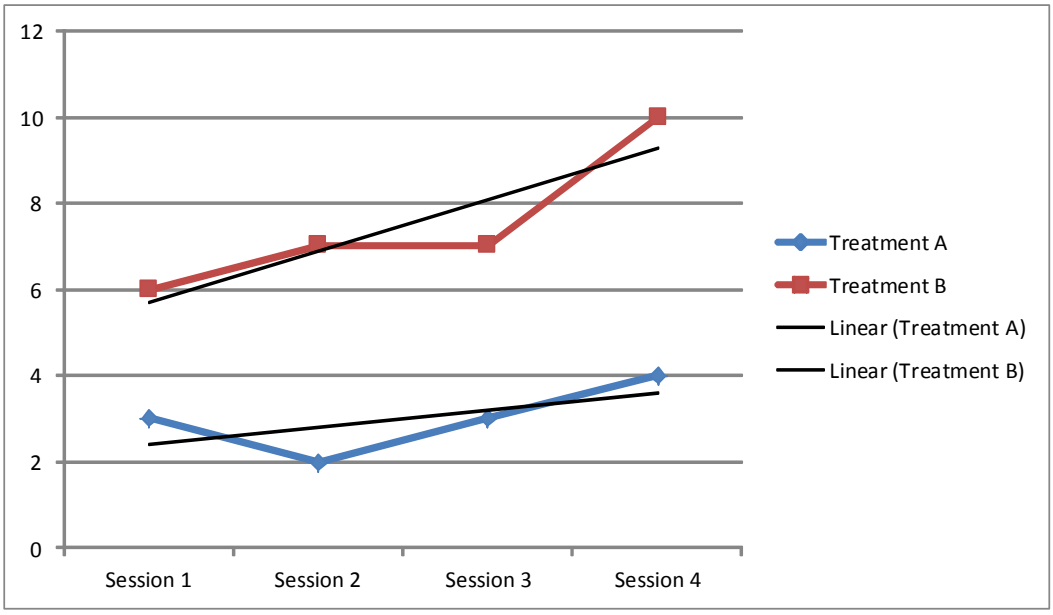

Figure 3. Graphic Representation of Lina's Word recognition Under Each Condition

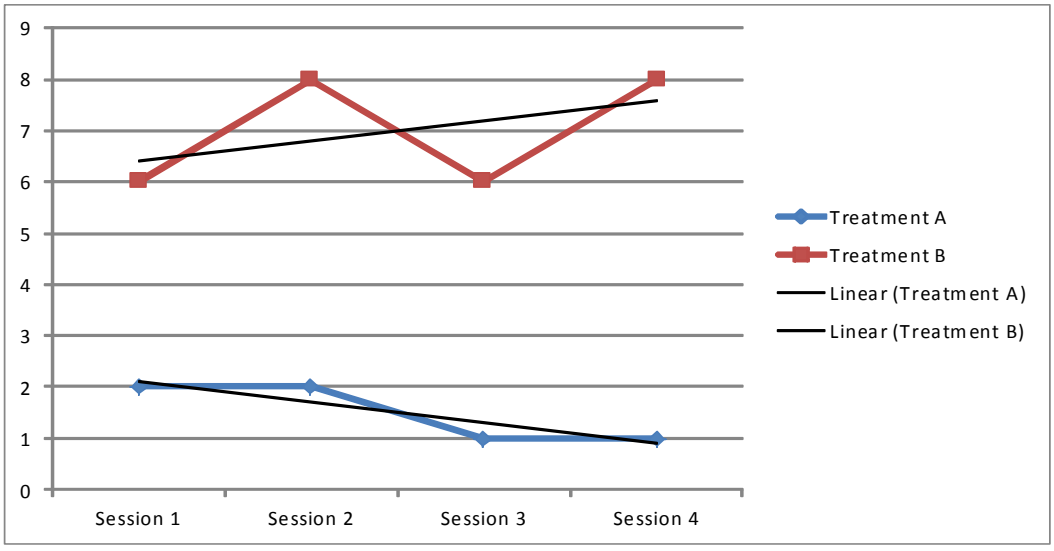

Figure 4. Graphic Representation of Jack's Word Recognition Under Each Condition

and steeper when compared to the Pinyin method. The replication of these findings clearly across three English-Chinese bilingual children with dyslexia suggests that these children with dyslexia consistently learn better via the Stroke method of teaching.

Discussion

This study's findings lend support to the suggestion that Pinyin instruction can impede the learning of morphemes in Chinese among English-Chinese bilingual children with dyslexia. Consistent with the findings of earlier studies (Solman & Adepoju, 1995; Solman & Chung, 1996), the learning rate is lowered when a Chinese word is paired with its Pinyin representation. However, there is a second, possible explanation for the findings. It is also possible that the difficulties with phonological processing, consistent with dyslexia in English (c.f., Vellutino, et al., 2004) could have impeded the facilitatory impact of Pinyin. The findings are consistent with the core impairment underlying dyslexia among English learners is phonological processing and that Chinese language, being logographic and orthographically deep, requires not phonological but rather visual processing skills. It is also possible that both accounts could have an additive impact upon the poorer performance across the Pinyin condition. Thus, whilst there is a clear finding of learning was poorer among the Pinyin condition, this study was unable to explain the reasons underlying these findings.

The findings are also consistent with the findings that developmental dyslexia can be language specific such that phonological processing deficits associated with dyslexia of learning alphabetic scripts such as English do not seem to impact upon the learning of reading in scripts of deeper orthography such as Chinese (Shu, et al., 2006). It is therefore important, to be specific about the underlying processes when identifying bilingual learners with dyslexia.

Implications for practice

Reasons aside, these findings point at one important implication – that English-Chinese bilingual children with dyslexia in this study learn Chinese words more poorly when Pinyin is introduced alongside Chinese characters. However, a large part of the Primary 1 Chinese curriculum involves the introduction of Chinese characters alongside Pinyin. This study findings suggest that the introduction of Pinyin for English-Chinese bilingual children with dyslexia might reduce the learning of Chinese word recognition of these children such that they are likely to be disadvantaged in the learning of Chinese. As such, there is a need to examine the pedagogy of introducing Chinese to bilingual children with dyslexia and/or the content of Chinese curriculum. It also has implications for the common practice of accommodations provided to children with dyslexia in Singapore.

Although some children with dyslexia receive an exemption from having to take the Chinese subject, most receive the accommodation after a few years in primary school. The findings of this study suggest that it may be helpful to receive the accommodation earlier or to learn Chinese in a different way.

Limitations and directions for future research

Although this study findings, replicated across all three participants, seem compelling, the small number of participants in this study limits the extent to which the findings may be generalized. As such, the replication of this study with more participants within a quasi-experimental study may help in understanding the extent to which these findings may be generalized.

Moreover, we had earlier indicated that the exact mechanism involved in the poorer learning of the Pinyin method is still unclear. In addition, we made an assumption that the observed difference in learning is indicative of learning difficulties when Pinyin is introduced alongside the characters rather than learning being enhanced by the Stroke method. Future studies comparing the performance of children with dyslexia against that of typically developing children across a variety of tasks comparing learning across methods can shed some light on this.

It is also possible that the Pinyin method of teaching where the presentation of the Pinyin transcription below the Chinese character may have distracted the participant from the task at hand. It may be helpful in exploring the possibility by adding a third condition with the English translation of the word, and a fourth condition with 'XXXX' or 'OOOO' written under the Chinese character.

Conclusion

Dyslexia impacts upon learning in many ways. In this study, we highlighted the complexity of this issue within English-Chinese bilingual children learning Chinese Pinyin. Specifically, we highlighted how the difficulties of developmental dyslexia manifest themselves differently in different scripts. However, these findings have also identified many other questions. Do these findings get replicated in different aspects of Chinese Pinyin learning? How can these findings guide the pedagogy of children with dyslexia? These remain to be answered but it is hoped that this study is one step in that direction.

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The Literacy Performance of Young Adults Who Had Reading Difficulties in School: New Zealand Data from the International Adult Literacy and Lifestyle Survey

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The performances of young New Zealand adults (16-24 years) with reading difficulties (RD; n=201) were compared with same-aged peers without reading difficulties (NRD; n=653) on measures of literacy in the Adult Literacy and Life-Skills (ALLS) 2006 survey. All in this sample had received their schooling in English and in New Zealand. The adults with RD were those who reported having received remedial or special class assistance for reading while in school. RD adults performed significantly less well than NRD adults on measures of prose and document literacy, numeracy, and problem solving. RD adults tended to have lower educational qualifications and lower status occupations than those who did not receive remedial reading. Differences in work-related literacy skills, health, and emotional wellbeing, were small to negligible, possibly because these correlates of literacy performance had not had time to become manifest. The RD adults tended not to choose or like reading when compared to their NRD peers. We considered literacy practices that were in place while these adults were in primary school, including remedial and special class interventions for children with RD, as contributing factors to the relatively poor literacy levels.

KEYWORDS: adult literacy; New Zealand literacy instruction; whole language; international adult literacy surveys

In response to results for New Zealand of the 1996 International Adult Literacy Survey (IALS) the Foreword to the document, *More than words: the New Zealand adult literacy strategy* (Ministry of Education, 2001), stated that "Too many New Zealanders lack the essential reading and writing skills to succeed in modern life and work" (p.2). Further, "one in five adult New Zealanders have very

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poor literacy skills" and high levels of literacy and numeracy are part of the basic skill set needed for participation in "our high-tech, knowledge society" (p.2). "Urgent action, sustained over the long-term, is needed to improve adult literacy levels in New Zealand. High levels of adult literacy are critical for the transformation and modernization of the New Zealand economy, and the transition to a knowledge society" (p.4). The IALS results for New Zealand indicated that approximately one million adults performed below the minimum level "of literacy competence required for everyday life and work" (National Centre for Workplace Literacy & Language, 2000, p.1).

The *More than words* document presented the adult literacy strategy, which focused on increasing the opportunities for adult literacy learning by providing significantly increased provisions for literacy improvement in workplaces, communities, and tertiary institutions (New Zealand Ministry of Education, 2001, p.3). The benchmark for success was specified as being improvement on a national measure of literacy similar to the IALS assessments carried out in 1996. The anticipated outcomes were expressed as follows:

"Beyond 2004, we will have established the necessary systems to ensure delivery of quality adult literacy teaching, *and will be beginning to reap the results of the investment in children's literacy at schools*. If another International Adult Literacy Survey were undertaken at that time *we should be able to say with confidence that New Zealand's results would be better than they were in 1996*" (Ministry of Education, 2001, p.7; emphases added).

Another international adult literacy survey was undertaken in 2006; the Adult Literacy and Life Skills survey (ALLS: Satherley & Lawes, 2007a). The current study examined whether the results of the ALLS survey were better than those from the 1996 IALS survey. Specifically, we focused on the literacy performances and lifestyle factors of young adults (16-24 years old) who indicated in the ALLS survey that they had received remedial assistance for reading while in school.

Adults between 16 and 24 years in the ALLS survey who received their formal education in New Zealand commenced school at 5 years of age between 1986 and 1995, the period of time during which the strongly whole language orientated approach to literacy instruction, as promoted in *Reading in junior classes* (New Zealand Department of Education, 1985), was in full use throughout New Zealand.

Further, the Reading Recovery programme was introduced in 1983 as a preventive means of substantially reducing the number of children who develop ongoing literacy difficulties (Clay, 1987). Clay (1987) made confident claims for the success of RR, stating that it is a "programme which should clear out of the remedial education system all the children who do not learn to read for many event-produced reasons [i.e., environment, cultural or economic causes] and all children who have organically based problems but who can be taught to achieve independent learning status in reading and writing despite this" (p. 169).

Pause, Prompt and Praise (PPP; Glynn & Wheldall, 1992; Wheldall & Glynn, 1989) was an additional programme introduced around the same time as RR. This programme uses parents or peers as tutors to assist older struggling readers who might not qualify for specialised remedial assistance. Like RR, the PPP programme was designed to complement New Zealand's whole language approach to literacy instruction, in which the relative emphasis in word identification strategies is on the use of sentence context cues rather than on grapho-phonic information.

For children who continue to make poor progress either in RR or at a later stage, Resource Teachers: Literacy (RT:Lit) may provide assistance. In addition to RT:Lits, there are Resource Teachers: Learning and Behaviour (RT:LB). Their role is to focus on the needs of students with difficulties in learning and/or behaviour. No formal criteria exist for identifying students for placement in either the RT:Lit or RT:LB programmes. Judgements regarding placement are typically made on the basis of day-to-day classroom teacher observations and assessments.

A number of adults in the youngest ALLS age group, especially those who indicated they had received help for reading, would have received tuition in the RR programme, and/or from RT:Lits, tutors in the *Pause Prompt Praise* programme, or from RTLBs. All of these programmes were introduced in the 1980s and 1990s to significantly improve the literacy performance of New Zealand children.

Smith and Elley (1994, 1997) considered that these programmes, based on the whole language approach, were world-leading. They wrote that "Cross-national surveys of reading achievement... have consistently shown that New Zealand achievement levels in reading are very high" (1997, p.110). These authors noted that expert commentators from other countries "have been fulsome in their praise of our reading programmes, our reading teachers, our reading materials and our Reading Recovery methods" (1997, p.110). They further stated that "our methods of teaching... are all spreading to other parts of the world.... It is no wonder that New Zealand is held up as a country whose reading programmes are best in the world [*Newsweek*, 1991]" (1997, p.110).

Given the link between literacy achievement in school and literacy performance in adulthood (e.g., Culligan, Arnold, Noble & Sligo, 2004, Pressley, 2006; Spear-Swerling & Sternberg, 1996), the positive effects of these reading programmes (e.g., Reading Recovery; *Reading in junior classes; Pause, Prompt, Praise*), should be observed in the ALLS survey data. Johnson (2000) commented that New Zealand's "renowned... innovations in children's reading and [its] recently initiated...children's literacy strategy" (p.8) would eventually flow through into improved adult literacy outcomes. Similarly, she referred to New Zealand's "renowned" Reading Recovery programme as a means of preventing "low literacy in the younger generation" (Johnson, 2000, p.9).

Not only is literacy achievement in school linked to literacy performance in adulthood, but also to post-schooling educational qualifications, employment

and income levels, well-being, and health (e.g., DeWalt & Pignone, 2005; Earle, 2010a & b; Kutner, Greenberg, Ying, Hsu & Dunleavey, 2007; Schogen & Lawes, 2009). In general, higher literacy levels are associated with higher educational qualifications, employment and income levels, and with more positive health and well-being indicators.

With these points in mind, our study addressed the following questions:

1. Did literacy achievement assessed in the ALLS survey for young adults in the 16 to 24 year age range improve compared to the same age group who participated in the 1996 IALS study?

2. How did young adults who indicated in the ALLS survey that they had received remedial assistance for reading difficulties compare with those adults who did not receive remedial assistance in terms of the ALLS literacy assessments?

3. How did young adults who received remedial assistance for reading difficulties compare with their same-aged peers who did not receive remedial assistance in terms of a range of life-skills variables included in the ALLS survey?

The ALLS Survey

Introduction

The Adult Literacy and Life Skills (ALLS) survey was a joint project of the Canadian Federal Government, the United States National Center for Education Statistics, and the OECD, involving 13 participating countries. The survey was constructed by the Educational Testing Service, in consultation with the government of each participating country (in New Zealand the Ministry of Education represented the government). The administration of the survey and treatment of data were overseen by Statistics Canada, and the National Research Bureau administered the survey in New Zealand in 2006 (Satherley & Lawes, 2007).

Stafford (2009) has presented technical information on the ALLS sampling procedure. He noted that in New Zealand a random, geographically-based "representative sample of 7,131 individuals aged from 16 to 65 years living in private households" (p.3) were drawn by selecting one adult from each selected household.

Satherley and Lawes (2007) reported that the ALLS survey was similar in content and purpose to the IALS. The prose literacy and document literacy measures used in the two studies are directly comparable, however, the quantitative literacy measure in the ALLS survey was different from that used in the IALS (Satherley & Lawes, 2007). In addition, a measure of problem solving ability was introduced into the 2006 ALLS survey.

Questionnaire

The ALLS questionnaire collected information on a range of demographic, educational, social, and economic factors, and assessments were made of literacy proficiency (Satherley & Lawes, 2007). *Prose literacy* was defined in terms of the knowledge and skills needed to

understand and use information from texts including editorials, news stories, poems and fiction. *Document literacy* referred to the knowledge and skills required to locate and use information contained in various formats, including employment applications, payroll documents, transportation timetables, maps, tables, and graphics. *Quantitative literacy* assessed the knowledge and skills required for the application of arithmetic operations to numbers embedded in printed materials, such as balancing a cheque book, calculating a tip, completing an order form, or working out the amount of interest on a loan based on information in an advertisement. *Problem solving skills* referred to the ability to reason and engage in analytical thinking in circumstances where no routine procedure existed.

Scores on each of the four domains ranged from 0 to 500, and were grouped into five levels. These levels were defined by score ranges and reflected the empirically determined progression of skills and strategies (Stafford, 2009). Because relatively small numbers of participants attained scores in the Level 5 band, Levels 4 and 5 were collapsed in the results for all countries.

Level 1 represented the lowest performance range, and Level 5 the highest. People performing at Level 1 have very poor skills and are likely to experience considerable difficulties in using many of the printed materials that they are likely to encounter in their daily lives. At Level 2, people would be able to use some printed materials, but these would be of a relatively simple nature. Performance at Level 3 is indicative of the ability to manage a varied range of materials found in daily life and at work. Not all printed material would be successfully dealt with at this level. People performing at Level 4 have good literacy skills, and demonstrate the capacity to use higher order skills associated with matching and integration of information. At Level 5, people have very good literacy skills, and can make high-level inferences, use complex displays of information, process conditional information, and perform multiple operations sequentially. Level 3 is considered to be the minimum level of proficiency required for meeting the complex demands of everyday life in knowledge-based societies (e.g., Lane, 2011).

Sample

The 16-24 year old sample in the ALLS survey was 1,082. Where we report data published by the New Zealand Ministry of Education, the results represent population estimates based on this sample. Where we performed our own analyses comparing those who received remedial assistance for reading with those who did not, we included only those survey participants who had received all of their formal education in New Zealand and in the English language. The resulting sample size was 854.

Within this sample were 201 (23.5%) who responded *yes* to the question: "Have you ever received remedial help or special classes with reading at school—regardless of the level of schooling?" (Q A10). They formed the reading difficulty (RD) group, and those who responded *no*, formed the non-reading difficulty group (NRD: n=653; 76.5%). Of the RD sample 57% (n=114)

were males and 43% (n=87) were females.

Results

Literacy Level Scores

To answer the first research question regarding whether or not the 16-24 year olds in the 2006 ALLS survey improved their literacy performances compared to their counterparts in the 1996 IALS study, we draw on data published by the New Zealand Ministry of Education.

Satherley and Lawes (2008a) reported that in prose and document literacy, the 16-24 year olds in 2006 "on average did not improve their performance compared to 16-24 year olds in 1996" (p.4). Satherley and Lawes (2008a) present data for prose literacy showing that 53% of 16-24 year olds performed at Levels 1 and 2, which was a marked increase in performance at the two lowest levels when compared to the 44% of 16-24 year olds in the IALS. A considerable decrease in the percentage performing at Levels 4 and 5 in the ALLS survey was also observed: from 20% in the IALS to 10% in the ALLS.

Turning to document literacy, Satherley and Lawes (2008a) noted that the skills of the youngest group in 2006 "did not improve compared to their counterparts in 1996" (p.9). Performance in Levels 4 and 5 decreased from 20% in 1996 to 13% in 2006. Increases were observed for performances in Levels 1 and 2, from 45% in 1996 to 48% in 2006.

Regarding numeracy and problem solving skills, data are presented only for the 2006 ALLS survey because the Numeracy measure was not equivalent to the 1996 IALS measure, and the measure of Problem Solving was introduced for the first time in the 2006 survey. Satherley and Lawes (2008a) report that 58% of 16-24 year old adults performed at Levels one and two for Numeracy, and 74% at these levels for Problem Solving.

In answer to the first question, the scores for Prose and Document literacy of young adults in the 2006 ALLS survey declined compared to those in the 1996 survey. In 2006, 53% of 16-24 year-olds scored at levels 1 and 2 for Prose literacy, compared to 44% in 1996. For Document literacy, 48% of this young group of adults had scores in levels 1 and 2 in 2006, compared to 45% in 1996. Across all four literacy domains assessed in the 2006 ALLS survey 48% to 74% of young adults performed at levels one or two, which is below the minimum level for adequate functioning in a knowledge society.

Group Comparisons: Literacy Measures

To address question two regarding the literacy performances of the RD group compared to the NRD group, we performed our own analyses using the STATTOOL SPSS programmes designed by Statistics Canada for analysing the ALLS data. We followed the guidelines presented by Statistics Canada (2002, pp.116-117) for treating literacy level scores that included five plausible values, replicate weights, and population weights. The level score percentages refer to population estimates.

For Prose literacy, 69% of the RD adults performed at levels one and two, compared to 49% of NRD adults. Only 31% of RD adults performed at levels three or

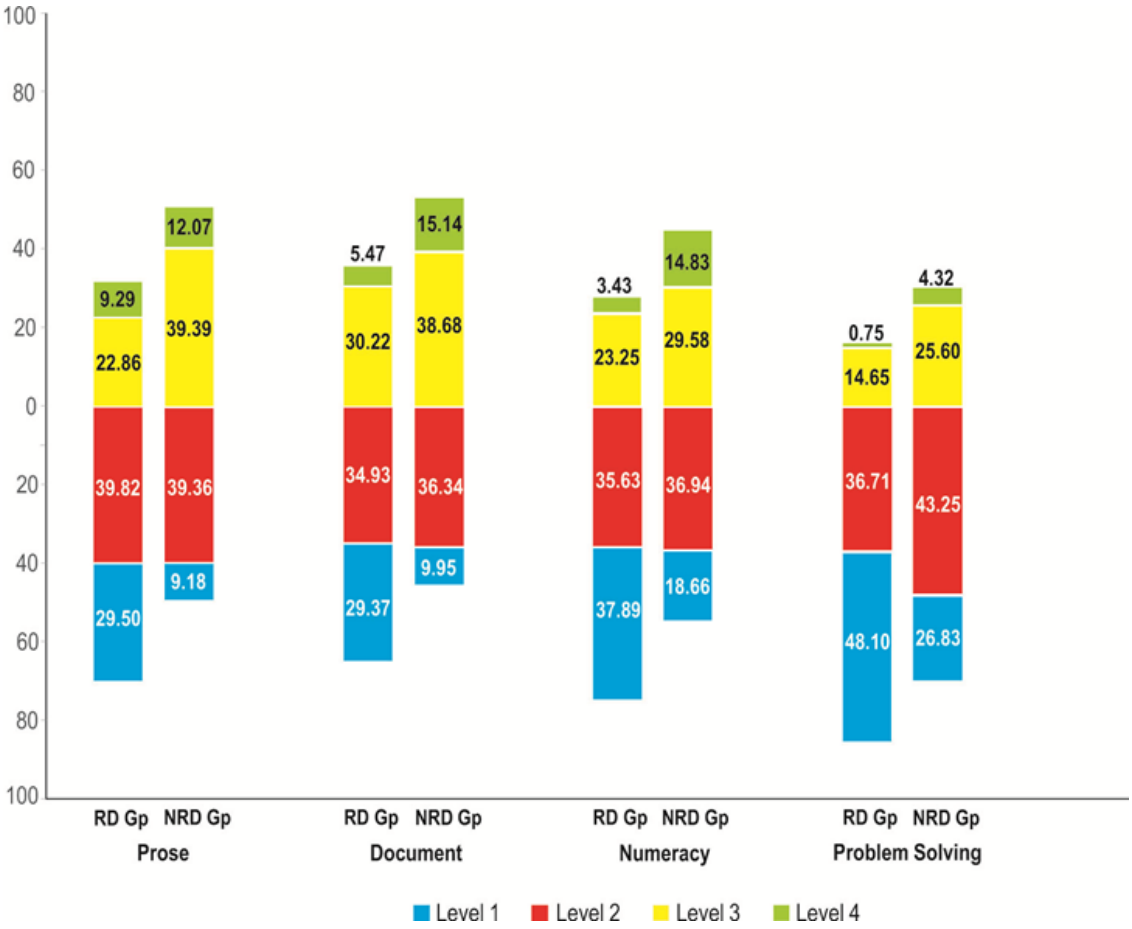

Figure 1. Literacy level score percentages as a function of RD and NRD grouping.

four/five. In contrast, 52% of NRD adults performed at levels three and four/five.

For Document literacy, 64% of RD adults, and 46% of NRD adults performed at levels one and two. For levels three and four/five, 36% of RD and 54% of NRD adults performed at these levels.

Regarding Numeracy, 74% of RD adults performed at levels one and two, compared to 56% of NRD adults. A small percentage of RD adults performed at or above level three (27%), whereas 44% of NRD adults performed above level two. High percentages of young adults in both groups performed at levels one and two for the newly introduced Problem Solving measure: RD group = 85%; NRD group = 70%. The comparative percentages for level scores for both groups on each variable are summarised in Figure 1.

Overall, both RD and NRD adults performed poorly in terms of percentages achieving at or above the level three minimum for competent functioning in a knowledge society. Clearly, however, RD

adults were considerably poor performers on all four measures included in the ALLS survey.

Group Comparisons: Life Skills

We compared RD and NRD young adults on a number of "life skills" variables, including educational level and qualifications, employment, reading-related skills and habits, health and income.

Around 20% fewer RD than NRD young adults completed year 12 or 13 at secondary school: 42% for RD compared to 62% for NRD young adults. Only 5% of RD young adults had completed one or more university degrees, whereas 14% of NRD young adults had done so. In response to the question (Q F1), "During the last 12 months, did you take any education or training", 56% of RD adults replied "yes", compared to 74% of NRD adults. Having reading difficulties is associated with lower levels of educational attainment, training and qualifications.

Despite having lower educational qualifications, RD young adults had similar levels of employment compared to NRD adults: 81% of RD adults were employed during the 12 months prior to the survey, compared to 84% of NRD adults. There were differences between the two groups, however, in regard to the status of occupations. Over twice as many NRD adults (29%) were in high status (professional, management) occupations than RD adults (12%). Conversely, over a third more RD adults (38%) were in low status occupations than NRD adults (24%).

Most adults in both groups received employment income from wages or salaries: RD = 77%; NRD = 80%. Related to the employment question is whether ALLS participants received any income from social assistance. Similar percentages (23%) of RD and NRD young adults received some form of social assistance income.

We analysed survey data for job-related reading skills. Just over three quarters of RD young adults (77%) indicated that they believed they had the reading skills in English to do their main job well (Q E4A), compared to 84% of the NRD young adults. A lower percentage of RD young adults believed they had the writing skills to do their main job well (Q E4B): 76% compared to 83% for NRD adults. These questions do not take into account the occupational status of adults in each of these two groups. Although these differences are important, the overall responses are positive.

In the home setting, it is interesting to observe that RD and NRD young adults reported having similar numbers of books in their household (Q G6). For households with fewer than 25 books 29% of RD adults and 27% of NRD adults responded in this category. Similarly, there was only a 4 percentage point difference for households with over 100 books: RD = 28%; NRD = 32%.

Reading preferences, however, showed clear differences between the RD and NRD young adults. In response to the statement "I read only when I have to" (Q G7C), 44% of RD young adults agreed compared to 28% of NRD young adults. A marked difference was also observed in

response to the statement, "Reading is one of my favourite activities" (G7D): 33% of RD adults agreed compared to 50% of NRD adults.

Two questions related to general well-being. In response to a question about health (G11), 89% of RD young adults reported that their health was good to excellent, compared to 92% of NRD young adults. Regarding general well-being ("Q G10: "On the whole, how do you feel about your life over the past 12 months?"), 71% of RD young adults reported satisfaction with their lives compared to 80% of NRD young adults. Literacy problems in school do not show a significant relationship with health and well-being post-schooling for young adults.

Discussion

The most startling finding from the 2006 ALLS survey is the generally poor levels of literacy among 16-24 year old adults, with this cohort of adults performing more poorly on the equivalent measures of prose and document literacy than their same-age counterparts in the 1996 survey. This result was in the opposite direction to that which was expected (New Zealand Ministry of Education, 2001). The literacy skills of these young adults, who would have started school at age 5 between 1987 and 1995, would have been shaped in schools when the whole language-based instructional approach to the teaching of reading in junior primary classes was firmly established throughout New Zealand. This approach to literacy instruction was proudly hailed as being "best in the world" (Smith & Elley, 1997, p.110).

In addition, the RR programme, introduced in 1983, was used in a large number of schools throughout New Zealand as a means to accelerate the reading progress of children at risk for developing reading problems, and thereby substantially reduce the number of children who develop ongoing reading and writing difficulties (Clay, 1987). Each year since its introduction, RR has served approximately 25% of the 6-year old (Year 2) New Zealand school population. Although the ALLS question regarding remedial reading did not seek information on the nature or duration of this support, it is reasonable to expect that many of those who indicated they had received help for reading, would have received tuition in the RR programme. The literacy performances of young adults in the New Zealand population at the time of the ALLS survey who had received help with their reading from one of a small number of generally whole language intervention programmes, including RR, were particularly disappointing.

The whole language approach to literacy instruction that was dominant in New Zealand schools in the late 1980s and throughout the 1990s (and beyond), and the establishment of RR in schools throughout New Zealand during the 1980s, correspond to the decline in literacy skills of the youngest group of New Zealand adults in the ALLS survey. The Ministry of Education described adult literacy as largely a function of the "output of an education system" (1997, p.2). Culligan, Arnold, Noble and Sligo (2004) in their analysis of 1996 IALS data found that the strongest predictor of was "overwhelmingly" educational attainment

(p.5). Literacy skills learned in school have the greatest impact on adult literacy, especially for those who most recently left school (Pressley, 2006; Spear-Swerling & Sternberg, 1996). Poor readers in adulthood usually have been poor readers in school (Spear-Swerling & Sternberg, 1996).

Despite the significant investment in school-based literacy instruction and remediation, the results of the ALLS survey should come as no surprise. New Zealand researchers (e.g., Tunmer, Chapman & Prochnow, 2003, 2004, 2006; Tunmer, Nicholson, Greaney, Prochnow, Chapman & Arrow, 2008; Tunmer & Prochnow, 2009) have argued that the dominant whole language approach to literacy instruction in New Zealand schools has been a major contributing factor to the relatively large literacy achievement gap that New Zealand has consistently shown in international studies of children's reading achievement over the past 20 years. They have also shown (Chapman et al., 2001; Chapman & Tunmer, 2011; Tunmer & Chapman, 2004) that the Reading Recovery programme has failed to fulfil its most important goals of accelerating the performance of children at-risk for developing ongoing literacy difficulties, and of "clearing out of the remedial education system" those children who struggle with learning to read (Clay, 1989). Given the relationship between literacy performance in school and literacy performance in adulthood, it follows that these negative effects should eventually be observed in international studies of adults' literacy performance, as they have.

The main flaw in the whole language and RR instructional approaches to the teaching of literacy in New Zealand schools is the "multiple cues" theory of reading acquisition. This approach, promoted by Clay (1979, 1987, 2005) and recommended in Ministry of Education publications (e.g., *Reading in junior classes*, 1985; *The learner as reader*, 1996; Effective literacy practice, 2003), stresses the importance of using information from many sources for identifying unfamiliar words in text, without recognizing that skills and strategies involving phonological information are of primary important in beginning literacy development. Instead, multiple cues theorists incorrectly assume that skilled reading involves the use of minimal word-level information for confirming predictions about unfamiliar words in text, and that a range of text-based cues (i.e., picture cues, semantic and syntactic sources of information, preceding passage context, prior knowledge and guessing activated by the developing meaning of the text) should provide the main means for figuring out unknown words (Clay, 1991; Smith & Elley, 1994). But, as Pressley (2006) pointed out, "the scientific evidence is simply overwhelming that letter-sound cues are more important in recognizing words... than either semantic or syntactic cues" (p.21), and that "teaching children to decode by giving primacy to semantic-contextual and syntactic-contextual cues over graphemic-phonemic cues is equivalent to teaching them to read the way weak readers read!" (p. 164). In an earlier edition of his text, Pressley (1998) described such an approach as "disastrous" (p.32).

Overall, the declines in the literacy

performances of young adults *are* disastrous. Considered together with the poor literacy levels of those young adults who had received remedial support for reading difficulties during their schooling, the significant changes in literacy instruction introduced into New Zealand schools during the time the young adults in the ALLS survey were in school appear to have been largely fruitless.

Regarding qualifications, employment and income levels, the differences between the RD and NRD were mixed. Young adults with RD generally completed their schooling at lower levels than NRD adults, attained lower post-schooling qualifications, and tended to have lower status occupations. Kutner et al. (2007) found that adults with lower levels of literacy tend to earn lower incomes and were likely to be out of the workforce more often than those with higher literacy levels. Earle (2010a) also found that higher literacy levels were generally associated with higher incomes, skills and qualifications. He noted that higher literacy and qualifications tend to be related and that increasing literacy levels without improving qualifications has limited value in the New Zealand labour market (Earle, 2010b).

Perhaps not surprisingly, the RD adults reported less preference for reading as an activity, with less than half agreeing that they only read when they have to and only a third agreeing that reading is one of their favourite activities. The effects of more limited reading compared to the NRD young adults may become more apparent over time as these young adults become older.

Differences between RD and NRD adults in terms of the reported number of books in their homes were negligible. This finding suggests that access to literacy resources is not necessarily a key factor associated with the RD adults receiving remedial reading during their schooling. Other factors, such as adequate instruction, declining motivation for reading and consequentially more limited reading experience possibly help to explain the need for remedial reading at school.

The relationship between having had remedial reading in school and overall well-being was negligible. Schogan and Lawes (2009), in their analysis of the full age range of New Zealand adults (16-65 years) in the 2006 ALLS reported that higher education and literacy levels "and/or" income were generally associated with better physical and emotional well-being. They also reported that having had remedial reading in school was associated with lower levels of physical well-being. These results were not observed for the young adults in the ALLS survey, suggesting that the relationship between literacy, health, and well-being may not develop until later in life, perhaps as life experiences and health issues become more challenging. DeWalt and Pignone (2005) reported for an American sample that adults with low literacy levels had less health-related knowledge, tended to show poor control over chronic illness, were less likely to receive preventive health services, and were more likely to be hospitalized.

One limitation of the present study is that no information was available in the ALLS survey about the nature or duration of

remedial reading received at school. While Reading Recovery was by far the most widely available intervention programme when these adults were at school, other programmes were also available on a much lesser scale. Almost all school-based programmes from the mid-1980s through to this first decade of this century were based on whole language principles. However, future surveys of adult literacy would benefit from more carefully crafted questions in relation to remedial reading to gauge the long-term relationships between reading interventions and subsequent literacy levels in adulthood. Indeed, given the widespread adoption of Reading Recovery and lack of controlled empirical evidence in support of the programme's efficacy (Chapman & Tunmer, 2011), a question in the next adult literacy survey asking respondents if they received RR would be beneficial from a policy and practice perspective.

Meanwhile, we hold that a change in the approach to literacy instruction in New Zealand schools based on overwhelming scientific evidence is overdue. Results from the 2006 ALLS survey showed a significant decline in literacy performance among young adults. These adults clearly did not benefit from the significant investment in school-based literacy programmes during the mid-1980s to mid-1990s, when they started school. Further, recent results from the 2011 Progress in International Reading Literacy Study (PIRLS: Chamberlain & Cagyill, 2012) provide additional evidence that New Zealand's "innovative" literacy policies have failed to lift the literacy performance of New Zealand children and adults. Without a major change in literacy instruction in New Zealand schools, poor levels of children's and adult literacy skills in New Zealand are likely to persist.

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The identification of Dyslexia in Pre-school Children in a Multilingual Society

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Given the importance of reading proficiency to literacy performance and beyond, dyslexia has received much attention in recent decades, fuelling vast research elucidating the factors underlying reading difficulties. Research has consistently demonstrated the importance and benefits of early intervention, hence underscoring the need for early identification of dyslexia. However, the existing research and the various early screening instruments developed were largely based on children in monolingual societies. This study examined the early identification of dyslexia in pre-school children in a multilingual society such as Singapore. The Dyslexia Early Screening Test – Second Edition (DEST-II), and the Cognitive Profiling System (CoPS) were administered to Kindergarten One and Two pre-schoolers. In addition, a rating scale on the children's literacy development was also administered to the teachers of these pre-schoolers. Preliminary results suggest that the DEST-II and the teachers' rating scale are effective and reliable first-line screening instruments in the identification of pre-school children "at risk" of dyslexia, albeit with some adaptations for use in the local context.

Keywords: Preschool screening, teacher rating scales

Reading proficiency is essential for educational success in school and into the later stages of life. Given the importance of literacy performance, an extensive amount of research has been conducted over the past few decades to understand and elucidate the factors underlying reading difficulties. In particular, the emergence of greater awareness and attention to dyslexia has fuelled vast research on this specific learning difficulty.

Dyslexia as a Specific Learning Difficulty

Dyslexia is a neurologically-based specific learning difficulty that interferes with the acquisition and processing of language that is not caused by a lack of

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intelligence or opportunities for learning (The International Dyslexia Association [IDA], 2002). It is characterized by difficulties in reading, spelling and/or writing that typically result from a deficit in the phonological component of language (IDA, 2002). Apart from these cardinal problems, there may be accompanying weaknesses in the areas of language acquisition, phonological processing, speed of processing, working memory, auditory and/or visual perception, sequencing and organization (The British Dyslexia Association [BDA], 2006). In addition, dyslexia is also associated with poor motivation, impaired attention and academic frustration.

The extent to which dyslexia is apparent in a particular language is a function of the quantity and quality of exposure to that language and other languages. Individuals with dyslexia are likely to have greater difficulty with languages of more complicated orthographic, phonological and/or grammatical systems. The incidence of dyslexia in Singapore is within the international range of 3% to 10% (Snowling, 2000). This translates to about 20,000 children in local primary and secondary schools, and another 3,500 children in pre-school education. In other words, an average of one to two students in every classroom of 40 students is estimated to be dyslexic and will need ongoing specialist teaching and support.

Identification and Assessment of Dyslexia

There have been a number of different approaches to diagnose dyslexia. Among these approaches, the Discrepancy and the Symptomatic approach emerge as the main ones used in identifying dyslexia. The advantages and disadvantages of each approach are discussed as follows.

The Discrepancy approach

As the mainstream methodology used to diagnose dyslexia, the Discrepancy approach identifies specific underachievement in a child's literacy attainments, in the areas of reading, spelling, writing and/or comprehension, relative to his or her intellectual capacity. Although this method is highly debated (e.g., Stanovich, 1994; 2005), it is nevertheless the diagnostic criteria that is reflective of mainstream definitions of the dyslexia construct (e.g., World Federation of Neurology, 1968) and is the diagnostic criteria set forth by the Diagnostic and Statistical Manual – Fourth Edition (American Psychiatric Association, 2000). In addition to an ability-achievement discrepancy, cognitive deficits including weaknesses in processing speed and working memory are also present.

According to this model, a diagnosis of dyslexia is made if the child's performance on various literacy tasks is significantly below what is expected given his or her cognitive functioning – a diagnostic criteria also known as the "wait to fail" model. Consequently, a child with an average level of intellectual ability yet demonstrates below average literacy performance suggests dyslexia. Likewise, despite age-appropriate literacy attainments, a child with high cognitive abilities may be found to be dyslexic as he or she is not performing up

to his or her potential academic ability. Accordingly, this approach provides a clear, direct and straightforward methodology for the identification of dyslexia.

On the other hand, to obtain a clear discrepancy between one's cognitive ability and literacy achievement, the child would have to experience failure and lag significantly behind in school. Relative to other children with no learning difficulties, these children typically receive less practice in reading (Allington, 1984), missed the opportunity to develop reading comprehension skills (Brown, Palincsar & Purcell, 1986), might have acquired negative attitudes about reading (Oka & Paris, 1986) or develop a low self esteem (Humphrey, 2002). Of greater importance is that once these children have delayed the development of critical word reading skills, it may require intensive interventions to improve and restore adequate levels of reading accuracy (Allington & McGill-Franzen, 1989; Vaughn & Schumm, 1996). This is further exacerbated by the large amount of reading practice that is lost with time as these children remain poor readers (Torgesen, 1998). Children who lag behind in the development of early reading skills have fewer opportunities to practise reading.

Recent evidence suggests that due to this loss of practice, it is extremely difficult for children who remain as poor readers during the first three years of elementary school to acquire age-appropriate levels of reading fluency (Torgesen, Rashotte, & Alexander, 2001). Consequently, recent studies have increasingly focused on the identification of dyslexia in early years to facilitate early intervention.

The Symptomatic approach

Through the identification of various characteristics and symptoms of dyslexia, the Symptomatic approach provides an alternative methodology to the assessment of dyslexia. According to this model, dyslexia-type symptoms such as literacy errors, phonological processing difficulties, sequencing difficulties, as well as poor working memory and motor skills provide a basis for a positive diagnosis. Using this approach, some early dyslexia screening tools aim to identify children who are "at risk" of dyslexia by examining some of these underlying deficits.

Several studies have documented various factors that strongly correlate with reading ability and reliably distinguish between successful and poor readers. Among these include phonological processing skills (Badian, 1998; Felton & Brown, 1990; Foorman, Francis, Shaywitz, Shaywitz, & Fletcher, 1997), short-term memory for words, digits and other verbally coded material (Fowler, 1991; Sawyer, 1992), and rapid serial naming skills (Wolf & Bowers, 2000). Other issues such as family history, speech development, birth history and socioeconomic status are also significant differentiating factors (Badian, 1988). In addition, research has also shown that a child's language experiences such as rhyming and sound game activities, as well as reading interactions, too influence the development of skills necessary for reading competence (Lonigan, Anthony, Bloomfield, Dyer, & Samwel, 1999; MacLean, Bryant & Bradley, 1987).

Apart from preventing the child from experiencing failure before help is given, the Symptomatic approach is particularly useful for the early identification of (and subsequently, the provision of early intervention for) dyslexia in young children such as pre-schoolers. This is especially so given that pre-school children would have rather limited literacy skills and are thus less likely to demonstrate a discrepancy between their abilities and attainments.

Singapore: A Multilingual Perspective

The identification and diagnosis of dyslexia in Singapore is compounded by multilingualism. With the rise and prevalence of globalization in the world, multilingualism and linguistic diversity have assumed a global identity. Consequently, the identification of dyslexia in a multilingual society such as Singapore has implications for all multilingual communities in many countries. Multilingual students live in an environment in which they are regularly exposed to, or need to use, two or more languages at home and at school. However, this does not imply that they are fluent in these languages or that they are competent and literate in any of these languages. In contrast, a monolingual student uses only one language at home and at school, but may learn a foreign language (or more) at school.

Within the local scene, the nature of the different languages used among various ethnic groups presents different problems. English and Malay are alphabetic languages; Chinese is a logographic script; and Tamil and Hindi are syllabic scripts. Due to cultural differences and the inherent confusion between different languages, children in Singapore are presented with great challenges as they negotiate between the local working language – English – and their respective Mother Tongues. Furthermore, given that English is adopted as the academic language and the main medium of instruction in school, many children coming from non-English speaking backgrounds, termed English-as-second-language (ESL), may encounter difficulties learning to read and spell as a consequence of limited exposure to the English language, rather than due to a specific learning difficulty such as dyslexia per se.

On the other hand, the identification of dyslexia in a multilingual society such as Singapore is almost always based on assessment and screening tools which were developed in monolingual societies. There are fundamental differences in linguistic, cultural, social and educational experiences between children in monolingual and multilingual societies. Consequently, it is important to determine if these tools can exercise adequate levels of diagnostic sensitivity and specificity by reliably distinguishing children with dyslexia from children presenting with other confounding issues that also contribute to literacy difficulties (e.g., ESL). The last decade has seen a rising interest in multilingualism and international cooperation and networking in research. This research suggests that dyslexia is a language-based disorder that may manifest itself differently in different language systems (Miles, 2000).

The Benefits and Importance of Early Identification of dyslexia

There is an extensive amount of research demonstrating the benefits and importance of early identification and intervention of reading difficulties. Early reading failure has been shown to have a broad impact on general cognitive development (Cunningham & Stanovich, 1998) and the demand for literacy in our technologically advanced society is increasing (Snow, Burns, & Griffins, 1998). Generally, the earlier the intervention, the easier it is for a child with dyslexia to learn to read, and the lower the incidence of psychological issues associated with reading difficulties. Research has demonstrated that children who were unsuccessful readers in first grade almost invariably remained as poor readers (Francis, Shaywitz, Stuebing, Shaywitz, & Fletcher, 1996; Juel, 1988; Torgesen & Burgess, 1998). Due to the fact that it is increasingly difficult to remediate reading difficulties as the child progresses into the later school years (Fletcher & Foorman, 1994), the gap between successful and poor readers widens over the elementary school years (Stanovich, 1986). The situation is further exacerbated by the persistence of reading difficulties throughout school and into adulthood (LaBuda & DeFries, 1988).

In contrast, children who are successful readers at the start of school are likely to experience academic success, graduate from high school and college and subsequently, seek employment after school (Slavin, Karweit, & Madden, 1989). Studies have consistently documented the benefits that early intervention yield in the acquisition of reading skills and on measures of reading and spelling (e.g., Ball & Blachman, 1991; Felton, 1993; Foorman, Francis, Fletcher, Schatschneider, & Mehta, 1998). Given the pivotal role of reading in a child's success in school and thereafter, and the benefits of early literacy intervention, the early identification of dyslexia in pre-school children is essential.

There are also some advantages of early screening tests. A screening assessment is a relatively short evaluation aimed at identifying children at risk of dyslexia, as compared to a detailed psychological assessment which usually occurs over two sessions. Accordingly, the former assessment is usually relatively inexpensive and may be administered by school professionals (e.g., teachers, special needs officers). This is in contrast to the latter assessment which requires a trained professional to administer. In addition, a screening assessment can also serve as a filter to identify children who demonstrate greater risk of dyslexia so that these children who require a detailed diagnostic assessment can go on to receive it.

Aim of Current Research Project

Taking into the consideration the complexities involved in the identification of dyslexia, it is both important and beneficial to ascertain the suitability and applicability of contemporary assessment tools to the local multilingual population. This is particularly so for those children who are not native English speakers. In addition, early identification of dyslexia in pre-school children leads to the possibility of early intervention aimed at preventing prospective failure in school

during later years. Consequently, the aim of the present research study is to investigate and review the best way to identify pre-school children in Singapore who are "at risk" for dyslexia. Two contemporary screening tools developed for pre-school children of this age range would be examined and compared: the Dyslexia Early Screening Test – Second Edition (DEST-II; Nicolson & Fawcett, 2004) and the Cognitive Profiling System (CoPS; Singleton, Thomas, & Leedale, 1996). These assessment and screening instruments were chosen due to their comprehensive coverage of the various symptoms of dyslexia, as well as their extensive use in the United Kingdom.

In addition, a rating scale of behavioural characteristics developed for use by teachers will be used to obtain information about the child's learning behaviour and performance in class. Teachers' ratings of behaviour and learning progress of a child in the classroom setting may play an important role in the early identification of children "at risk" for dyslexia. Such reports have been frequently used as part of comprehensive diagnostic procedures such as that for children with general learning difficulties (e.g., Myklebust Pupil Rating Scale; Margolia, Sheridan, & Lemanowicz, 1981) and Attention-Deficit Hyperactivity Disorder (e.g., Conners' Teacher Rating Scales – Revised; Conners, Sitarenios, Parker, & Epstein, 1998). Through the administration of these instruments and rating scale, the present study aimed to examine and elucidate the effectiveness of these tools in identifying pre-school children who are "at risk" for dyslexia, including the consistency in identification outcomes among these different instruments.

Method

Participants

Kindergarten One and Two pre-schoolers, aged between 4 years 6 months and 6 years 5 months, from one kindergarten and four childcare centres in Singapore were included in the study: (1) St. James' Church Kindergarten; (2) Learning Vision @ Punggol Field Walk; (3) NTUC Childcare Bukit Merah; (4) NTUC Childcare Bedok; and (5) NTUC Childcare Jurong West. These centres were selected to obtain a representative sample and include children from diverse backgrounds. With the assistance of these selected centres, letters of consent including information about the study and some questions about the child's background information were sent to parents. A total of 136 children participated in the study upon parental consent. However, the final sample of children who completed the study was reduced to 119 following the language screening test.

Materials

Rating Scale. A rating scale was constructed based on the major characteristics of dyslexia commonly displayed by pre-school children. At the pilot phase, feedback was collected from a few kindergarten teachers and principals to ensure that all items are comprehensible. A few changes were made to the wording of the items and the revised version of the rating scale comprised 21 items covering the following area of difficulties: (i) phonics;

(ii) reading/spelling/writing; (iii) speech; (iv) motor skills; and (v) general. Teachers were instructed to rate the child on the respective dimensions based on his or her performance relative to same-aged peers, using a 5-point frequency scale anchored at the ends with 1 = Never and 5 = Always.

British Picture Vocabulary Scale – Second Edition (BPVS-II). The language screening procedure was conducted through the administration of the BPVS-II (Dunn, Dunn, Whetton, & Burley, 1997). The BPVS-II is designed for use with children from age three to 15 years and is used to measure a child's level of English receptive vocabulary. Each item has four simple black and white illustrations on a page arranged in a two-by-two array. The child is simply required to select the picture that is considered to best illustrate the meaning of a target word presented orally by the examiner.

In order to exclude the confounding influence of language comprehension on task performance, an exclusion criterion was adopted to screen out children who may have problems understanding and following the instructions on subsequent test instruments. In particular, children with BPVS scores of less than 70 (more than two standard deviations away from the mean of 100) were excluded from the study.

Dyslexia Early Screening Test – Second Edition (DEST-II). The DEST-II (Nicolson & Fawcett, 2004) is a dyslexia screening instrument intended for use with children aged between 4 years 6 months to 6 years 5 months. It was designed to identify children "at risk" for reading failure early enough so that they can be given extra support in school.

The DEST-II comprises 12 subtests which assess the child's ability in the areas of phonological awareness and discrimination, pre-reading skills, motor skills, rapid naming ability, working memory, spatial sequential memory, balance ability, receptive vocabulary and verbal reasoning. These tests were based on a review of the literature on dyslexia and chosen to include a sufficiently comprehensive range of skills found to be impaired in individuals with dyslexia (e.g., Bishop, 1985; Denckla & Rudel, 1976; Fawcett, Maclagan, & Nicolson, 2001; Wolf & Bowers, 1999). Performance on each subtest is reflected by an "At Risk Index", which is used to compute an overall "At Risk Quotient" (ARQ) ranging from 0 to 2. An ARQ of 0.9 or greater is strong evidence of being "at risk" of dyslexia, and an ARQ of 0.6 to 0.8 is mild evidence of being "at risk".

For the purpose of this study, only 10 out of the 12 subtests were administered. The Postural Stability subtest was excluded due to concerns about the administering procedure – blind-folding and touching the child's body – which may be intimidating to the child. In addition, the Vocabulary subtest as a measure of receptive vocabulary and verbal reasoning was excluded as the BPVS-II was already administered. Furthermore, given that some children come from a non-English speaking background, including the Vocabulary subtest may not provide as adequate an indication of dyslexia in Singapore as in other monolingual societies.

Cognitive Profiling System (CoPS). The CoPS (Singleton, Thomas, & Leedale, 1996) is a computer-based standardized assessment instrument intended for use with children aged between 4 years 0 months to 8 years 11 months. It is designed for use by individuals trained in the field of education or psychology to identify children's cognitive strengths and weaknesses. The gathered information can assist in the identification of dyslexia, various developmental difficulties and other special educational needs so as to recognise the child's learning style and provide them with individualized and differentiated teaching.

The CoPS consists of nine tests delivered in the form of games to assess the following areas of cognitive ability: visual/verbal sequential memory; visual/spatial sequential memory; auditory/visual associative memory; auditory/verbal sequential memory; visual/verbal associative learning; phonological awareness; auditory (phoneme) discrimination; colour discrimination; information processing speed; and motor processing. Each test is preceded by verbal instructions delivered by the computer, followed by a practice phase in which the child is told by the computer how to play the 'game'. A mouse practice activity is incorporated into the program to provide an opportunity for the child to practise moving and clicking the mouse. This is especially important for children with no experience using a computer mouse.

Procedure

Stage 1: Pre-testing & Pilot

All the researchers went through a period of training to familiarize themselves with the administration and scoring procedure for the BPVS-II, DEST-II and CoPS. Each researcher then conducted a trial run and administered these instruments to a volunteer.

Stage 2: Checklist & Screening

Teachers' Rating Scale. Rating scales were distributed to the teachers through the principals of the selected centres. With the exception of those children whose parents had opted to be excluded from the study, teachers were requested to rate each child individually using the rating scales provided.

Screening Procedure. All children with parental consent to participate in the study were administered the BPVS-II during the first session of testing. Those who scored exceptionally poor (BPVS < 70) were excluded from the next stage of the study.

Stage 3: Experimental Testing (Sessions 2 to 5)

The final sample of children was then administered the DEST-II and CoPS. Due to the rather long administration time needed for the COPs (approximately 45 minutes to an hour; as compared to the DEST-II which takes about 20 to 30 minutes), and the relatively shorter attention span of young children, the CoPS was subdivided into CoPS1, CoPS2, and CoPS3 to be completed in three separate sessions in that order, as shown in Table 1. Each sub-session comprised a combination of visual and auditory/verbal tests. In addition, all children were

Table 1. Breakdown of CoPS into three different sessions

CoPS1	CoPS2	CoPS3
(Mouse Practice)	Toybox*	Rabbits*
Clown‡	Rhymes†	Zoid's Letter Names†
Zoid's Friend*	Zoid's Letters*	Races†
Wock†		

**Visual Tests; †Auditory/Verbal Tests; ‡Colour Discrimination*

Table 2. Age, Gender Distribution, BPVS scores and Race Composite by Pre-school Centre

Characteristics	Centre 1 (n = 13)	Centre 2 (n = 12)	Centre 3 (n = 14)	Centre 4 (n = 40)	Centre 5 (n = 18)	Total Sample (N = 97)
Age at 1st test (years)						
M	5.43	5.09	5.60	5.32	5.34	5.35
SD	0.47	0.48	0.53	0.52	0.50	0.52
Gender						
Male	6	5	8	23	8	50
Female	7	7	6	17	10	47
BPVS-II Score						
M	99.77	102.25	85.86	88.23	91.17	91.71
SD	11.28	13.78	8.09	9.57	9.78	11.55
Race Composite						
Chinese	13	11	10	33	13	80 (82.5%)
Malay	0	1	1	6	5	13 (13.4%)
Indian	0	0	3	1	0	4 (4.1%)

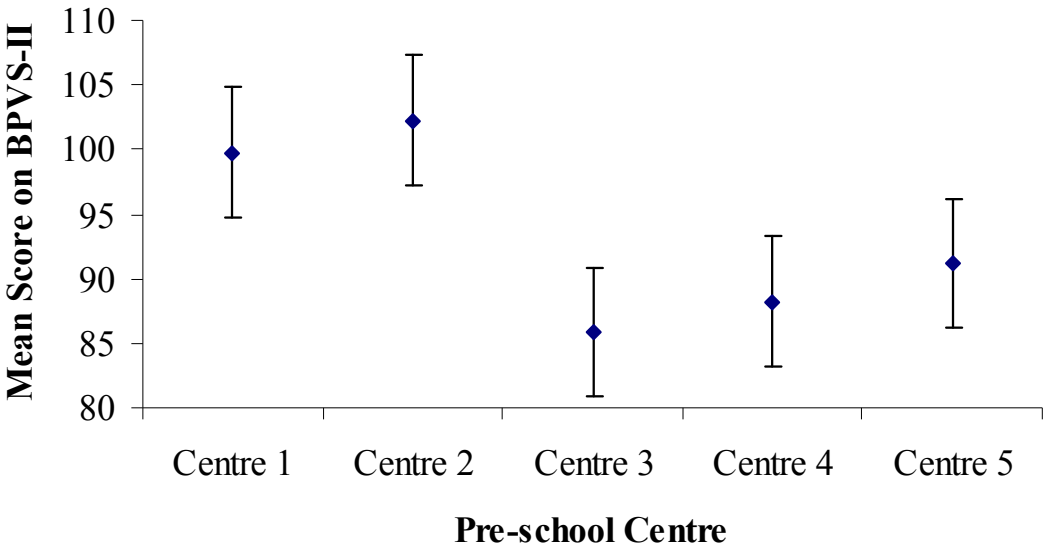

Figure 1. Mean scores on BPVS-II by pre-school centre. 5% error bars are shown.

required to complete the mouse practice activity before commencing any of the actual tests.

Results & Discussion

Prior to any analysis, the collected data from the various instruments were screened. For the purpose of preliminary analysis, children with missing data from any of the instruments administered (i.e. teachers' checklist, DEST-II, CoPS) were excluded from data analysis. These included one child who was consistently absent from school and another who withdrew from school and thus, did not participate further in the study. Consequently, the final sample size used for data analysis was reduced from 119 (following language screening using BPVS -II) to 97.

Participant Characteristics

Table 2 provides a summary of the demographic characteristics and level of receptive vocabulary of the children from the five pre-school centres. There were no significant differences in age (at first testing), $F(4, 92) = 1.70$, ns, nor gender distribution, all $c2(1) < 0.90$, ns, between the children from the five pre-school centres.

However, at the centre level, these children were significantly different in terms of their level of receptive vocabulary reflected by the BPVS-II scores, $F(4, 92) = 7.49$, $p < .001$ (see Figure 1). A further analysis of these scores revealed that children from

[1] *With the exception of Centre 1 and Centre 5. There was no significant difference in BPVS scores between these pre-school centres.*

pre-school centres 1 and 2 scored significantly higher than children from the other three centres[1]. In retrospect, while the five pre-school centres were recruited from five different regions in Singapore, there may arguably be differences in the socioeconomic status of its residents. Specifically, pre-school centres 1 and 2 are situated in Holland Village and the new estate of Punggol respectively. In comparison, centres 3, 4 and 5 are situated in more mature and established housing estates. Almost all tested children from the former group of centres came from an English-speaking background (92% to 100%) as compared to a lower percentage of such children from the latter group centres (50% to 66%). On the other hand, pre-school centres 3, 4 and 5 saw a relatively greater proportion of children from a non-English speaking or ESL background (more than 70% in these centres versus 46% in pre-school centres 1 and 2).

CoPS

Taking into consideration the short attention span of pre-school children, each of the five sessions of testing was limited to twenty minutes. In addition, the original CoPS was divided into CoPS 1, 2 and 3 to be administered over three shorter sessions. Nevertheless, it was observed that many children required close supervision when completing the CoPS and they had to be constantly reminded to remain focused on the task at hand. Their inattention and distractibility appeared to have affected their performance on the various tasks. Although almost all children were fascinated by the attractive pictures and sounds presented using the laptop during the initial presentation of each sub-test, they lost interest quickly as the items presented were getting more difficult, or as the target stimuli that they should remember increased.

In addition, the nature of the CoPS is such that on the main test items, the child is required to produce a response on the computer mouse and subsequently, he/she can then proceed to the next item regardless of whether the answer is correct. On the other hand, the practice items required the child to produce a correct response, upon which the failure to do so would see the practice items being repeated over and over again until a correct answer is recorded. Many children were observed to engage in random responding when unsure or when their attention drifted.

Consequently, the results on the CoPS are not reported as they did not appear to be reliable and preliminary analyses of the collected data revealed several inconsistencies that question the validity of the results. In general, at least at the preliminary level of analysis, the CoPS does not appear to be as an effective tool for the purpose of identifying pre-school children "at risk" for dyslexia, in view of the aforementioned issues.

Teachers' Rating Scale

The rating scale was completed by each participating child's school teacher to obtain an understanding of the child's day-to-day performance in school. It was noticed that some checklists contained missing data as the teachers did not complete every item. This could be due to the possibility that some items were not

Table 3

Total Rating Scale Score by Pre-school Centre

	Centre 1 (*n* = 13)	Centre 2 (*n* = 12)	Centre 3 (*n* = 14)	Centre 4 (*n* = 40)	Centre 5 (*n* = 18)	Total Sample (*N* = 97)
M	25.92	33.25	69.57	40.05	33.11	40.29
SD	8.21	9.63	16.77	11.01	18.36	18.3
Percentile						
10th	20	21.9	44	25.2	21.9	22
25th	20.5	24.5	57	30	22	24.5
50th	23	29.5	69.5	38.5	23.5	37
75th	28.5	44	84.25	49	40	50.5
90th	42.8	44.7	92.5	54	66.8	65

Table 4

"At Risk Quotient" on DEST-II by Pre-school Centre

	Centre 1 (*n* = 13)	Centre 2 (*n* = 12)	Centre 3 (*n* = 14)	Centre 4 (*n* = 40)	Centre 5 (*n* = 18)	Total Sample (*N* = 97)
M	0.1	0.18	0.62	0.23	0.36	0.23
SD	0.1	0.16	0.38	0.17	0.23	0.26
Frequency(%) of:						
Strong risk (ARQ>0.9)	0	0	5 (35.7)	0	0	5 (5.2)
Mild Risk (0.6<ARQ<0.8)	0	0	1 (7.1)	1 (0.025)	4 (22.2)	6 (6.2)
No Risk (ARQ<0.6)	13 (100)	12 (100)	8 (57.1)	39 (99.075)	14 (78.8)	86 (88.7)

applicable to the school curriculum or that the teachers had no chance of observing the child carrying out certain activities. Alternatively, the teachers might have accidentally missed out some items.

A preliminary analysis of the distribution of scores on each item suggests that a number of items had a very positively skewed distribution. In general, about 10% of the scores lie within the extreme high end of the distribution. However, considering that dyslexia occurs in about 3% to 10% of the population, the results from the rating scale appear to be in accordance to prevalence statistics. Given a 5-point rating scale with 21 items, possible total scores on the rating scale range from 21 to 105, with higher scores indicating a higher frequency of the stated difficulty. Table 3 presents the descriptive statistics for total rating scale score by pre-school centre. Reliability analysis revealed high internal consistency (Cronbach's a = 0.956) of the items on the rating scale.

One-way ANOVA revealed significant differences between pre-school centres on total rating scale scores, $F(4, 92) = 23.39$, $p<.001$. Post-hoc analysis demonstrated that children from pre-school centre 3 scored significantly higher on the rating scale relative to children from all the other pre-school centres. Notably, children from pre-school centre 4 scored significantly higher than children from pre-school centre 1.

DEST-II

On the DEST-II, the distribution of scores on some of the subtests was rather skewed. In addition, it appeared that Singaporean pre-school children generally performed better on tests assessing motor coordination skills, digit span, letter naming and digit naming. In contrast, they did significantly poorer on tests that assessed their phonological awareness, especially rhyme. Consequently, the ARQ, which was calculated based on the child's overall performance on the DEST, may not be a valid representation of the child's abilities in these areas in which many dyslexic individuals have difficulties. Table 4 presents the descriptive statistics of the DEST-II ARQ by pre-school centre.

One-way ANOVA revealed significant differences between pre-school centres on ARQ scores on the DEST-II, $F(4, 92) = 12.78$, $p<.001$. Post-hoc analyses demonstrated that children from pre-school centre 3 scored significantly higher ARQs relative to children from all the other pre-school centres. Children from pre-school centre 5 scored significantly higher ARQs than children from pre-school centre 1.

Relationship between Instruments

To examine the consistency in identification outcomes across the different instruments, and the influence of children's language backgrounds on their level of performance, scores on the rating scale, DEST-II and BPVS-II were compared and examined. Pearson correlations revealed a significant relationship between scores on the rating scale and DEST-II, $r(97) = 0.63$, $p < .001$, and this correlation remained significant when differences in BPVS-II scores (i.e. the influence of receptive vocabulary)

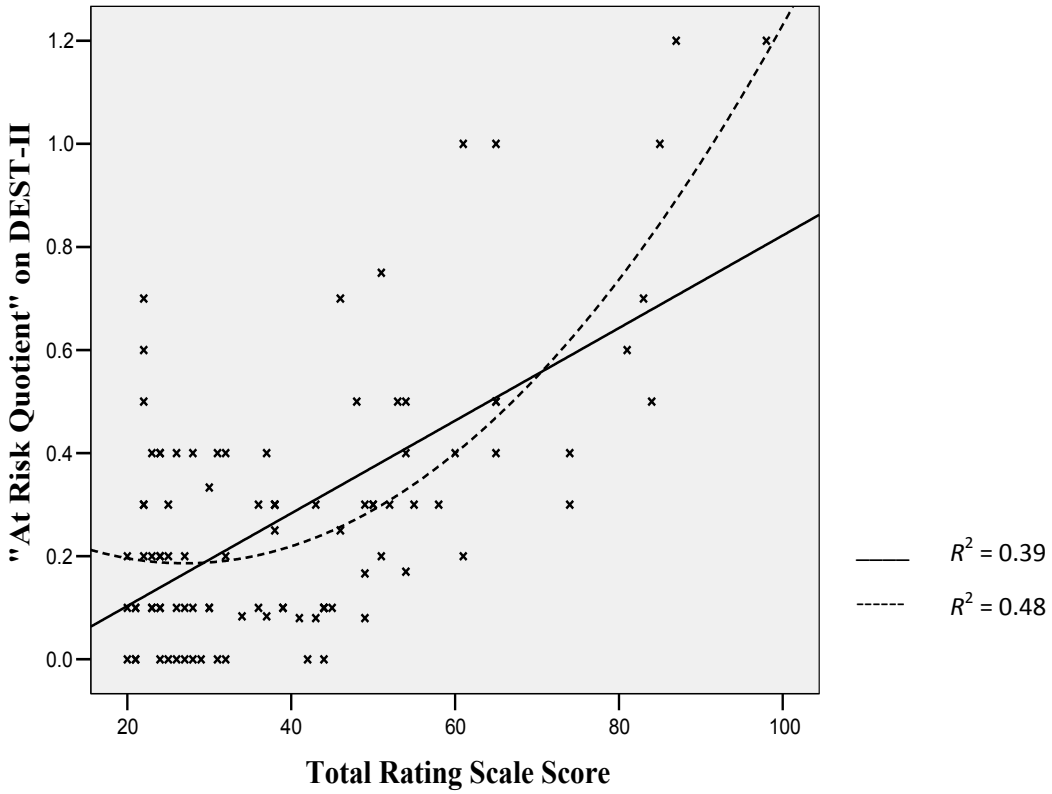

Figure 2. "At Risk Quotient" on DEST-II plotted against total rating scale score. Linear and quadratic regression functions are fitted to the data.

were partialled out of the relationship, r (94) = 0.58, p < .001. This suggests that a child who is found to be "at risk" on the DEST-II was also rated as demonstrating more difficulties by the teacher. This is a genuine and direct association that is not mediated by the child's receptive language.

It could be argued, that the teachers' teaching experience of pre-school children might have affected their responses on the rating scale and hence mediated the association between total rating scale scores and ARQ on the DEST-II. However, correlational analysis suggest that this relationship remained strong when the teachers' teaching experience was partialled out of the association, r(89) = 0.56, p < .001. Taken together, it appears that there is consistency between a child's ability as reflected by the teachers' rating scale, and the child's performance on the DEST-II. At least at the preliminary level of analysis, there appears to be between-

instrument reliability in identifying children "at risk" of dyslexia.

A scatterplot was obtained using the total rating scale scores and DEST-II ARQ. Regression functions were then calculated to determine whether a linear or quadratic function could significantly account for the data. Figure 2 illustrates both the resulting scatterplot, and regression lines.

There is a clear effect of teachers' rating scale on the child's ARQ on the DEST-II, which was significantly accounted for by a moderately strong linear function, $R2 = 0.39$, $F(1, 95) = 60.93$, $p < .001$. This revealed that the teachers' rating of the child's performance and behaviour in class is a significant and moderately strong predictor of the child's "at risk" index on the DEST-II. Interestingly, a quadratic regression function significantly accounted for more variance of the ARQ on the DEST-II, $R2 = 0.48$, $F(2, 94) = 43.00$, $p < .001$. However, more research and data is needed before any inference can be drawn from this finding.

In general, the DEST-II appears to possess great potential for use as a screening instrument to identify pre-school children "at risk" of dyslexia. The DEST-II requires a relatively short administration time and has a straightforward scoring and interpretive procedure. Also, given that it is intended for use by school professionals such as teachers and special needs coordinators, it provides a cost-effective method of conducting large-scale screening projects. Finally, preliminary results suggest the effectiveness of DEST-II in identifying Singaporean pre-school children "at risk" of dyslexia, albeit with some adaptations for more applicable use in the local context.

Future Directions & Avenues for Research

More research is needed to look into further modifications of the DEST-II for effective use within a multilingual society. With the increased prevalence of multilingual communities in many countries as a result of globalization, the potential and implications of this research are far-reaching and significant. Given that pre-school children in Singapore appear to perform better on some subtests and worse on others, future research can examine the best combination of subtests that produces the greatest ability to identify "at risk" children. Subsequently, it is important to establish the ease and reliability of the administration of the DEST-II as an initial screening instrument by teachers in pre-school settings. The same applies to the teachers' rating scale which requires modifications based on the preliminary analyses and observations from the current study. Eventually, it is envisaged that the revised DEST-II and teachers' rating scale will serve as first-line screening instruments that are effective and reliable in the identification of dyslexia in pre-school children in a multilingual society such as Singapore.

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Sustained Benefits of a Multi-skill Intervention for Pre-school Children at Risk of Literacy Difficulties

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Children at mild risk for literacy difficulties (n=32, mean age 4.1 years) were identified using a multi-skill screening battery. The majority – the intervention group - had small group support (15 minute sessions twice weekly for 10 weeks), while the control group experienced the standard nursery group. The intervention comprised four 'streams' – language and phonics, memory (auditory and visual), gross motor skills (balance, imitation and catching) and fine motor skills (pegboard, tool use and fine pencil work). Both groups performed equivalently at pre-test. An immediate post-test showed mean standard score improvement for the intervention group (93.1 to 106.2), by contrast with controls (96.9 to 98.5). Mean effect sizes for the two groups were 0.88 and 0.23 respectively. Significantly greater improvements occurred for gross motor skill, memory, and phonology including rhyming, but not for fine motor skill, pre-literacy and speed which improved significantly in both groups. After 18 months, sustained improvements were found in memory, a key predictor of success in early learning, as well as in gross motor skill. The results suggest that a balanced, multi-skill intervention may be particularly effective for pre-school children.

Keywords: Pre-school screening, early intervention, learning difficulties, screening tests,

Introduction

This paper addresses the key issue of whether or not screening and intervention is feasible and worthwhile for children at age 4, before they start formal education. There is now considerable evidence throughout the school years that the earlier literacy-related problems are identified, the more effective, and the more cost-effective, interventions are likely to be (National Reading Panel, 2000; Snow Burns and Griffin, 1998; Torgesen, 2001). Summarising a range of

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studies of support of children with severe literacy difficulties (Alexander, Anderson, Heilman, Voeller and Torgesen, 1991; Lovett, Lacarenza, Borden, Frijters, Steinbach and DePalma, 2000; Rashotte, McPhee & Torgesen (2001); Torgesen, Alexander, Wagner, Rashotte, Voeller, Conway and Rose, (2001, 2004); Truch, 1994; Wise, Ring & Olsen, 1999), Torgesen (2001) estimates that an hour's intervention at age 8 is likely to lead to a gain of 0.20 points in standard score on word identification and 0.30 points in phonemic decoding. He concludes that an intensive 70 hour intervention may be seen as 'normalizing' the problems – accelerating the child back into the normal range of achievement. By contrast, interventions with older children tended to be 'stabilizing' rather than normalizing the difficulties [Kavale, 1988], and led to very modest mean gains. We have provided a range of short term small group intervention studies for children aged 6 and above which proved highly successful (Nicolson and Fawcett, 1999). In the light of the 'stitch in time saves nine' nature of this relationship, we decided to investigate whether still earlier intervention – in the pre-school period - is likely to lead to prove effective.

The skills with which a child enters school are highly predictive of future progress, (e.g. Vellutino & Scanlon, 2002; Whitehurst & Lonigan 2001; Denton & West 2002). Consequently, preschool has been identified as a key period (McCardle & Chhabra, 2004) to ensure that children enter school ready to learn to read. There is limited evidence available on the impact of intervention with preschool children, although explicit attempts to train up aspects of phonological awareness preschool lead to improved outcomes in literacy (Byrne, Fielding-Barnsley & Ashley, 2000). Evidence suggests that children 'at risk' of failure on phonological and orthographic skills can be 'inoculated' by intervention in kindergarten (Coyne, Kame'enui, Simmons and Harn, 2004; Outdeans, 2003; Schneider Roth and Ennemoser, 2000; Smit-Glaude, van Strein, Licht and Bakker, 2005). Studying economically at risk children in pre-kindergarten established that pre-school children benefit from a program that emphasises social-emotional, motor and cognitive skills (Molfese, Modiglin, Beswick, Neaman, Berg, Berg and Molnar, 2006).

Pre-school intervention suffers from the obvious difficulty that it is not clear at the pre-school stage which children are most likely to have literacy difficulties, and consequently it may be necessary to provide an intervention for a greater proportion of the cohort than considered necessary with older children. For some years we have argued that a two stage approach to this problem is the most cost -effective, based on the development of an appropriate screening test with relatively wide scope, followed up by an intervention for those children screened as at risk. In earlier research, (Fawcett, Nicolson, Moss, Nicolson and Reason, 2001; Nicolson, Fawcett, Moss, Nicolson and Reason, 1999) we established that screening children in school at age 6 (using the Dyslexia Early Screening Test, Nicolson and Fawcett, 1996) followed by targeted short-term intervention can significantly assist most children at risk of reading failure. A 10 week intervention at age 6 led to an improvement of 3.8

standard score points in WORD (Rust, Golombok and Trickey 1993) reading standard score. This equates to 0.38 standard score units per hour instruction (around twice the improvement reported by Torgesen, 2001). Cost effectiveness was additionally quadrupled by using groups of 4 children. The fact that the support personnel were teachers rather than highly trained phonological support specialists lends further cost savings, leading to a cost-effectiveness perhaps 10 times those reported in the literature. It is important, however, to note that one is not 'comparing like with like' in this comparison. Although all low performing children in the screening were supported, their problems were by no means as entrenched as those considered by Torgesen.

The research reported here adapted the above approach to the preschool period. The methodology involved included formal, controlled, small group comparisons, together with the evaluation of a screening-support system. In brief, a skill-based screening test was administered (PREST, Fawcett, Nicolson and Lee, 2001), and an intervention package delivered to children who showed problems in pre-reading skills. Children were also given a test of receptive vocabulary (British Picture Vocabulary, BPVS – Dunn, Dunn, Whotton and Pintillie, 1982), as a rough measure of verbal IQ. The children's progress was followed from age 4yrs to 5yrs 8 months in all, and progress compared with a control group drawn from the same nursery who had received no intervention beyond normal nursery experience. This approach has similarities to Bailet, Rapper, Piasta and Murphy, 2009 who demonstrated significant improvements in emergent literacy in a major study of phonological intervention with 220 prekindergarten children identified as 'at risk' for reading failure based on their performance on screening tests between the ages of 4 and 5. Our study worked with even younger children aged just 4.1. There are both theoretical and applied justifications for using a multi-skill screening and intervention with children of this age range, to measure a broad range of aspects of 'readiness to learn' which can impact on progress in the early years,

Five main issues were addressed: (i) whether the screening and intervention process was feasible with children as young as 4 years; (ii) whether it proved effective and cost-effective; (iii) whether any improvements were sustained in the years post-intervention; (iv) to establish benchmarks for future research; and (v) to identify pointers for subsequent developments.

Method

Participants

Two cohorts of children were screened in two Sheffield nursery schools sharing the same academic program and environmental input. The schools were Broomhall Nursery (Nursery 1) and its annexe, Mushroom Lane nursery (Nursery 2). Both nurseries work to the same timetable, share planning meetings and follow the same rationale for the methods they adopted. The schools were selected for their existing links with the university and for their willingness to allow access to a nursery research worker taking

children out to work in pairs in a small room. These inner city nurseries cater for 120 children aged 3-5, they are funded by the local education authority so that parents do not pay fees, and draw from a mixed catchment area, including high rise flats and rented accommodation as well as private housing. Children are drawn from diverse ethnic backgrounds, with around 20% in total of Asian or African background, and 11% were entitled to free school meals. 22.5% had EAL (English as an alternative language), and 11% Special (educational) needs. None of the SEN or EAL participants were included in this study; they formed a separate group whose outcomes are not reported here. Both schools are well rated for their outcomes in terms of language and literacy, mathematics, and personal and social development, with children at school entry above the level expected for the average 5 year old.

Based on the screening, intervention was undertaken with 20 children screened as most 'at risk' based on the PREST test (Fawcett, Nicolson and Lee, 2001). A control group of 12 children was also identified, matched for initial scores with the intervention group (3 of the control group were not available at post-test because they had moved away from the area, and so only 9 controls are included in the analyses). Mean data for the intervention and control groups respectively were as follows: Age: mean 4.06, range 3.9 to 4.3, sd 0.01; control mean 4.22, range 4.1 to 4.3, sd 0.05. British Picture Vocabulary scores: mean 102.1, range 80-127, sd 13.67; control mean 103.6, range 82-127, sd 14/62. Gender balance: intervention 12M 8F; control 4M, 5F.

Nursery 1 was asked to identify all children of the appropriate age, parental permission was sought for participation in the study, and children were screened using the Pre-School Screening Test (Fawcett, Nicolson and Lee, 2001). This test (PREST) was based on a simplified version of the DEST that is suitable for 4.5 plus (Fawcett, Nicolson and Lee, 2001) and was developed for children aged 3.5 upwards in school. The test takes around 30 minutes to administer and produces a profile of strengths and weaknesses in comparison with age referenced norms. Ten children from cohort 1 were selected for intervention on the basis of risk scores of 0.4 or greater, given the prototype intervention over a 10-week period, and their performance was checked again. Having established the feasibility of the approach, in the second phase, Nursery 1 contributed the control group, and a second cohort was screened for intervention in Nursery 2. The control group included the children in Nursery I in the age group 3:9-4:3 to match the intervention group.

Design

Performance of the intervention and control groups on the screening test was measured both before and after the 10-week training period. The critical variable was the amount of improvement for the experimental group and the control group from pre-test to post-test. The control group received standard nursery school experience, which involved no structured support. The differential improvement of the experimental group would give an indication of the effectiveness of the intervention. In addition, a further 'delayed screening

test' was undertaken when the children reached the age of 5:8 using the DEST (Nicolson and Fawcett, 1996) in order to assess the extent to which any improvements were maintained in the absence of further interventions.

The training regime was designed for children working in groups of two in two/three weekly sessions of around 15 minutes, over 10 weeks, with the interventions taking place within the normal nursery session. Nursery attendance was two hours daily (10 hours per week). The intervention group and the control group therefore shared 90-95% of the nursery environment, with the remaining time allocated to the intervention activities for the intervention group and general, professionally administered, nursery activities for the controls. In terms of criteria (McCardle and Chabra, 2004) the design is more rigorous than a 'quasi experimental' design, in which the control group have no intervention, but less rigorous than a 'clinical' design, in which alternative interventions are pitted against each other. In our view, it represents a reasonable compromise in that it provides an appropriate estimate of what gains might be made within an established educational system by targeted short-term interventions.

a) Screening

Screening and intervention were delivered by a nursery nurse, with no specialist training but with an interest in special needs. Screening was carried out using the Pre-School Screening Test (Fawcett, Nicolson and Lee, 2001). The PREST was developed by combining simplified components of the Dyslexia Early Screening Test (Nicolson &Fawcett, 1996), a screening test for children from 4.5 to 6.5 years, with some components from the Middleton-in-Teasdale Screening Test (MIST, Lee, 2004), a comprehensive but time-consuming battery. Ten two- or three-minute tests were used from PREST, eight of which were based on DEST: two tests of pre-literacy [digit naming, in which the digits 4, 3, 5, 7, 6 are shown and the number read correctly is recorded], and letter naming (c a t s r and first letter of child's name); two tests of phonological awareness [rhyming in which children are asked to identify the rhyme in a nursery rhyme, and pick out the odd one from sets of three pictures, and phonemic discrimination, in which pairs of phonemically confusable (or identical) words are spoken by the tester, and the child has to say whether they are the same or different]; speed of processing (the Rapid Automatised Naming test in which the child has to say the names of a set of 20 pictures of common objects as fast as possible]; Memory (verbal memory including a standard digit span test, and spatial memory via the 'Corsi frog' test in which the child has to remember which 'lily pads' a frog jumps to]; fine motor skills [bead threading speed and scissor use, and shape copying accuracy] and gross motor tasks (heel-to-toe balance and catching and hopping) from the DEST/MIST were adapted to include simple balancing tasks, and a Romberg test (standing on both feet with one foot in front of the other) appropriate for children of this age group. The tests therefore cover literacy, cognitive and motor domains together with visual, auditory and kinaesthetic modalities.

b) Assessment

Participants were assessed using the PREST at age 4:0 (pre-intervention) and again at 4:4 (post-intervention). For the follow-up at 5:0 and 5:8 they were assessed using the Dyslexia Early Screening Test. The PREST is a simpler version of the DEST for a younger age group, the DEST has commonalities with the PREST and so the data are comparable. The DEST comprises 11 sub-tests in five areas (literacy skills, phonological awareness, verbal memory, motor skill and balance, and auditory processing). The sub-tests are as follows. Digit names tests knowledge of digits 1-9, Letter names tests knowledge of t, s, d, e, w, o, b, q, n, y. Rhyme tests both for understanding of rhyme and of first letter sounds; Rapid naming involves the time taken to speak the names of pictures on a page full of common objects; Discrimination is the score on saying whether word pairs such as 'fuse' and 'views' are identical. Digit span tests verbal memory for sequences of digits. Beads is the number of beads threaded in 30 s; Postural stability reflects the degree of movement when pushed gently in the back; Shape copying tests the accuracy of copying simple geometrical shapes. Sound order tests the ability to determine which of two sounds played shortly after each other was first. The overall DEST score is essentially the average of the scores on the individual sub-tests.

c) The intervention

The intervention was developed by the first two authors based on a whole school intervention (Middleton Rescue Package, MIRP, Lee, 2004), modified and extended for small group work. It is important to highlight the fact that four year old children are still in a phase of rapid development of a range of cognitive and motor skills. Consequently, although in assembling the intervention battery we were placing strong emphasis on language based skills, we aimed to cover the full range of the nursery school curriculum, including skills that may also underpin motor and cognitive development. Furthermore, in order to be successful, it was important to engage the attention and co-operation of young children with no experience of formal schooling, and very short attention span.

Intervention took place in groups of two, for around 15 minutes. All children had at least 2 sessions weekly. The 13 children with moderate risk scores on PREST had two sessions of language support, and one of motor skill per week with the remainder having only two sessions per week. In each session three skills were presented to maintain variety and interest, and maximise learning. The intervention researcher adapted the program to the needs of the children, spending longer on games which the children clearly enjoyed. At each stage care was taken to provide the right mixture of familiarity and challenge, so that children were exposed to new skills. Skills trained by both language and motor intervention explicitly included a range of concentration and listening skills. The aim of the intervention was therefore to introduce a more explicit teaching element, and to encourage all children to take part, while maintaining the element of fun which is crucial for success at any age. Above all, instant

reinforcement and feedback was provided.

Rationale for the training methods adopted

The link between language difficulties and learning disabilities is well established (see the report of the National Reading Panel). The rationale for motor skills intervention was based on a whole school intervention package developed by the second author and his colleagues (the Middleton-in-Teesdale Intervention and Rescue Programme, 2001), that had proved particularly effective in previous school-based outcome evaluations. We focused here on a combination of language and motor skills appropriate for learners in the early stages of development. Although both gross and fine motor skills were included, the training was set up in such a way that all children had more language than motor skill input, with a ratio of around 70:30 language to motor, and all motor skills intervention included aspects of language. In other words, an integrated program of skills was devised and delivered as a generic program to the children in the intervention group.

Activities included:

i) Language and Phonological Activities. Tasks included segmentation, phoneme identity and blending using their own name, finding initial sounds, rhyming, ear training, sequencing, tongue twisters linked to letter sounds

ii) Cognitive and Memory Activities: tasks included auditory and visual memory, prepositions with small plastic coloured bears, memory games, opposites, miming, copying patterns, associating geometric shapes on different properties including shape, size, colour and thickness.

Iii) Gross Motor Activities. Balancing on the wobble board (a wooden board balancing on runners, which can be adjusted to make it more or less difficult to balance), playing 'Simon says' (a game where the child follows the spoken directions only if they are preceded by the phrase 'Simon says') and trying to catch bean bags or throw them at skittles.

iv) Fine Motor Activities included colouring in, peg board, sewing, hammering, sequencing, and Graphisme (filling in a picture with dots).

In later weeks, children were encouraged to pit themselves against a stop-watch or an egg timer, not only to emphasise the need to work quickly, but also to assist concentration.

It is important to note that, following the intervention, it was considered that 5 children continued to have difficulties. These were then given support for a further four weeks. This intervention was delivered to children individually, targeted at their areas of particular difficulty. It is also important to note that the interventions delivered are not commercially available, and represent a generic approach that can be modified as required to suit the teacher/ participants.

Table 1. Mean performance of the intervention group and controls on subtests of the PREST pre and post intervention, together with performance of the intervention group at a follow-up at age 18 months later. (Standard deviations are in parentheses)

	Pre-literacy	Speed	Phonology		Memory		Fine Motor Skill		Gross Motor Skill	
	Digits & letters	Rapid Naming	Phon Disc	Rhyme	Digit Span	Corsi frog	Beads & Cutting	Shape Copying	Balance	Catch & jump
Intervention Pre	101.35 (15.44)	101.00 (15.05)	97.83 (19.57)	97.24 (14.89)	94.57 (11.48)	92.64 (12.69)	104.33 (14.57)	87.62 (11.87)	87.50 (14.31)	67.11 (21.77)
Intervention Post	109.69 (13.28)	107.63 (9.47)	108.98 (18.76)	119.50 (16.86)	108.75 (13.26)	104.23 (9.73)	110.86 (10.12)	97.76 (9.51)	103.91 (14.41)	91.07 (18.35)
Effect Size	0.60	0.47	0.61	1.57	1.34	0.87	0.47	0.82	1.02	1.01
Control Pre	98.75 (16.83)	100.09 (16.69)	99.21 (10.69)	97.00 (13.69)	98.13 (10.64)	93.79 (18.18)	113.80 (10.60)	91.93 (10.11)	101.30 (18.19)	74.69 (33.60)
Control Post	105.65 (10.23)	105.82 (11.68)	103.16 (15.29)	96.17 (13.23)	97.29 (8.70)	92.27 (16.51)	111.60 (11.22)	93.93 (12.88)	97.68 (18.48)	81.25 (23.49)
Effect Size	0.49	0.47	0.29	-0.06	-0.08	-0.11	-0.16	0.16	-0.23	0.29
Intervention Follow-up	100.46 (10.72)	98.87 (9.39)	104.04 (17.75)	107.06 (7.44)	114.23 (14.30)		105.36 (26.12)	112.84 (7.66)	100.88 (11.22)	
Control Follow-up	105.89 (3.41)	91.65 (26.16)	106.04 (9.62)	108.24 (7.07)	107.94 (14.13)		101.90 (20.90)	110.21 (4.85)	85.03 (19.07)	

Data analysis

The 'raw' scores on the PREST sub-tests at pre-training and post-training were converted into age-adjusted standard scores using the conversion data available in the normative sample. In order to highlight the different skill domains, the separate sub-tests were also combined to give scores on six skill domains: pre-literacy, phonology, memory, speed, fine motor skill and gross motor skill. Following a multivariate analysis of variance of the pre- and post-training scores for the two groups, individual two factor analyses of variance were undertaken on the separate sub-tests, with the aim of identifying for which skills the intervention group improved significantly more than the control group (revealed by a significant interaction between group and time-of-test). In order to provide quantitative estimates of the amount of improvement, changes in standard score were calculated. In addition, effect sizes of the improvements were calculated for each group by dividing the group change in standard score by the standard deviation of the cohort on the initial test (Cohen, 1977). Corresponding standard score analyses were undertaken at the 5:8 follow-up using the DEST data.

Results

The means and standard deviations of the standard scores for both groups at pre- and post-training test, together with the corresponding effect sizes, are reported in table 1 below, and illustrated in figure 1.

If we consider first the control group, it may be seen that they have made some progress overall. Their mean standard score improved from 96.9 to 98.5 (mean effect size 0.23). There was a clear 7 point improvement in digit and letter knowledge, but other scores showed variable changes. By contrast, the intervention group showed improvements across the board, with a mean improvement from 93.1 to 106.2 - with a minimum increase of 6.6 points and notable increases (10 points or more) in all but Rapid Naming, Beads & cutting and digits & letters. The mean effect size was 0.88.

In terms of inferential statistics, the multivariate analysis on the six skill domains indicated that significant interaction effects (using Wilks' lambda) occurred for: phonology, memory and gross motor skills. [$F=5.83$, $p<.05$, $F=18.63$, $p<.001$; $F=4.57$, $p<.05$] but not for pre-literacy, speed or fine motor skill [highest $F=1.95$, NS]. Significant effects of time-of-test were found for pre-literacy, phonology, speed, fine motor skill and gross motor skill [$F=6.32$, $p<.05$; $F=7.56$, $p<.05$; $F=5.44$, $p<.05$; $F=7.78$. $p<.05$; $F=4.37$, $p<.05$ respectively] but not for memory [$F=1.52$].

The above analyses reflect group differences rather than individual differences. It was therefore of particular interest to assess the pattern of changes at the individual level. We categorised each individual score on a sub-test as 'at risk' if it fell one standard deviation or more below the mean (a standard score of 85 or less). Any individual with 30% or more of their PREST scores ≤85 was categorised 'at risk' overall. Overall risk incidence fell from 65% to 5% for the

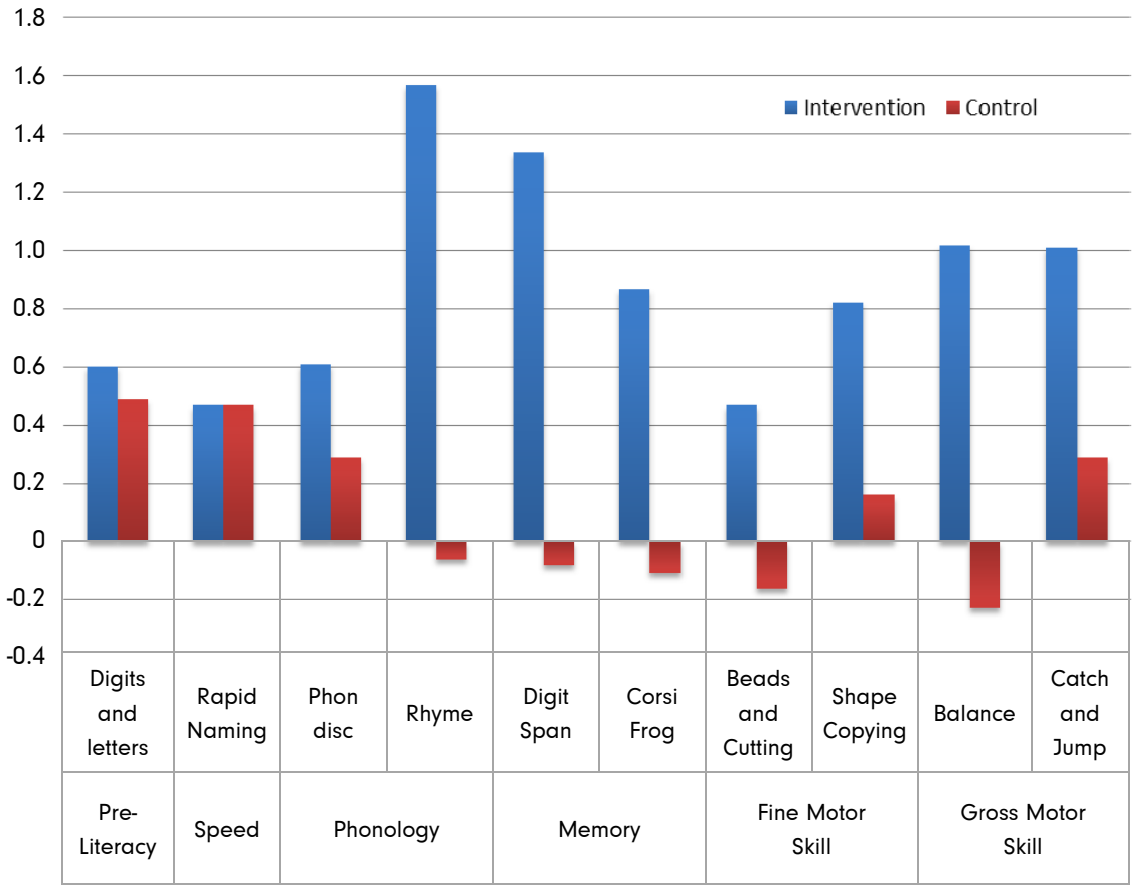

Figure 1. Effect sizes for improvement pre/post for intervention and controls. An effect size of 0.2 is small, 0.5 is medium, and 0.8 or more is large (Cohen). It may be seen that some skills improve in both groups, but others seem to deteriorate in the control group without explicit support.

intervention group, and from 42% to 33% for the control group.

Follow-up tests at 5:8 years

As noted above, the groups were followed up roughly 18 months after the end of the intervention in order to establish whether the improvement in performance was sustained after the intervention finished, or, as is most common in such cases, whether they slipped back toward their original performance levels. The standard score data are shown in the bottom lines of Table 1 (with 18 of the intervention group and 9 of the controls). It may be seen that in general the mean standard scores were indeed sustained. There were drops of over 5 points in pre-literacy and in rhyme (but that is not surprising in that there are ceiling effects on these tests at 5:8, in that it is impossible to score over 110). There was also a drop in rapid

naming. Otherwise scores remained the roughly same or improved. The minimum standard score was 98.87, easily within the normal band. None of the 18 individuals was at risk, with only one individual having more than one at risk score out of the 9 measures.

In general the control group also made satisfactory progress over the period. The most notable differences from the intervention group derive from the low mean scores for rapid naming and for balance, which arise from poor scores from 7 individuals within the group (2 for rapid naming and 5 for balance). Two of the 9 had at risk scores on 2 of the 9 tasks, with 6 of the remainder having one at risk score.

Interestingly, the intervention group continued to show an advantage in memory in comparison with controls, based on standard scores 7 points higher overall. Despite being significantly poorer than controls at pre-test on digit span, the effect size for the intervention group was 1.37 compared with the control effect size of -0.08. Memory is notoriously difficult to improve, and the research was careful not to teach the test, encouraging instead a series of listening skills, and memory games such as "I went to market and I bought' which builds up an alphabetical sequence which each child must correctly repeat, while adding the next letter in the alphabet. These games are suitable for use by parents as well as pre-school teachers to enhance auditory memory development.

Overall Discussion

Five key issues were noted in the introduction. We consider them in turn.

(i) Feasibility of the screening and intervention process

Clearly this minimal requirement was satisfactorily met. It should be stressed that this was by no means a foregone conclusion, in that a very abbreviated intervention program had to be developed suitable for working in 15-minute periods two to three times per week. The participants enjoyed both the screening and the intervention, as did the intervention researcher!

(ii) Effectiveness

The maximum time in the intervention was 45 minutes for 10 weeks – 7.5 hours. From a child's perspective therefore 7.5 hours' intervention led to a mean increase of 12.1 standard score points, or 1.6 standard score points per hour intervention. Given that the children were seen in pairs, one can double this figure to obtain the cost-effectiveness, namely 3.2 standard score points per hour. These are extraordinarily strong findings, suggesting that it would be entirely feasible to screen and support many times as many children at age 4 than if one waits for the problems to become entrenched by age 8. A stitch in time truly saves 9 in this case.

(iii) Maintenance of improved performance

The 18 month follow-up suggested that none of the intervention group had any problems at 5.8 years. There appears to be some evidence of a diminution in processing speed, but otherwise all the

skills appear to have been maintained.

(iv) Benchmarking of interventions at age 4

One of the major contributions of the National Reading Panel (2000) was to 'benchmark' interventions, so that it should be possible to predict the expected improvement for different types of interventions. The Panel expressed their findings in terms of effect sizes of gains for phonological awareness, single word reading accuracy and fluency and comprehension. Torgesen (2001) produced the further important refinement in terms of cost effectiveness (that is, effect per hour of instruction) as introduced by Nicolson et al, (1999). To our knowledge, there are no corresponding benchmarks – in terms of effect sizes or standard score improvements, for 4 year old children, and indeed we are not aware of any benchmarks at any age for skills such as memory, speed, fine and gross motor skills. Consequently, even though these data are based on a very small sample of children we hope that they will provide a start in this important endeavour.

(v) Directions for further research.

One of the most intriguing issues raised by this research is that, based on one of the author's (Lee) decade of first hand experience of the value of including gross and motor skill practice within a balanced intervention program, we made our intervention very much broader (and shallower) than those normally advocated. This study in itself can yield little direct evidence relating to the differential value of including interventions for skills at best indirectly related to literacy. Nonetheless, there is consistent evidence within the literature that broadening an intervention to include say fluency as well as reading leads to consequent advantage (Berninger, Abbott, Vermeulen and Fulton, 2006; Fawcett, Moss, Nicolson, Reason and Nicolson, 2001; Hatcher, Goetz, Gibbs and Smith, 2006; Nicolson, Fawcett, Moss, Nicolson and Reason, 1999; Nicolson 2001; Wolf, Miller & Donnelly, 2000). It would clearly be an important research priority to replicate the present study with larger numbers of participants and with differing types of intervention so as to explore these issues systematically.

One further issue is the degree to which it is valuable to make skills explicit. One of the goals of the intervention was to be explicit at all times, not only articulating what the target performance was, but also whether the child was achieving it. It seems that the standard nursery curriculum (at least in the UK) simply exposes a child to a range of experiences. We conclude, with Molfese and colleagues (2006) that it is important that material is delivered explicitly for children at risk of failure, because they are less well equipped to extract implicit information.

A final intriguing issue is why it was that the intervention group showed gains 'across the board'. It is probable that this reflects the breadth of the multi-skill intervention, but it is also possible that there were gains in meta-skills that underlie improved school performance. In particular, based on anecdotal records maintained for each child, we noted that the intervention group learned to listen, to

do what the researcher/nursery nurse asked, and to seek appropriate feedback on their performance. In other words, they were learning how to learn! (Fawcett, Nicolson, & Lee, 2004) This is a key requirement for success in the early years at school. Some evidence for this view derives from further measurements that we have not reported here owing to the lack of suitable norms, because these subtests were not included in the published PREST. There were striking improvements for the intervention group in repetition memory (the ability to repeat a sequence of words). 100% of the intervention group improved, 75% achieving near perfect scores by contrast with scores of zero at pre-test, whereas performance of the controls remained unchanged.

The study reported here fits in particularly well with current moves in policy in the UK, towards a broader curriculum in the early years. It has been particularly relevant in Wales in terms of the new Foundation phase that emphasises the need for outdoor play before formal literacy teaching is introduced. It is an approach that seems to be simple, effective and cost-effective, and further studies are now in progress using this approach. 35 schools in South Wales have now adopted this model with 5 year olds, with considerable success (Jones and Fawcett, 2013), and a new intervention package based on this is now available (Hands on Literacy, 2012).

Implications for the Asian Pacific region

Children here start school later, and there is an expectation that their literacy skills will be well developed by the time they start formal schooling, with a variable range of support available for children in pre-school. A similar approach could be particularly useful in the pre-school period in countries where children start school later, thus ensuring that all children can fully benefit from instruction by the time school starts. Most children at risk of dyslexia need specific and explicit support individually or in small groups in order to make the progress expected of them and keep pace with their peers on school entry. The skills outlined here must be in place before any more formal literacy learning can take place. These are the principles behind moves towards pre-school support for children at risk for dyslexia on early screening tests as advocated by the Dyslexia association of Singapore.

Limitations of the study

It should be acknowledged that this was only a small-scale study, that it reflects real world limitations in subject attrition, notably in the control group, that we have no information on any support provided from home, and intervention was delivered by only one person, who had no specialised training in intervention of any type. If these findings could be replicated in larger studies, it seems that screening and intervention might prove a key factor in prevention of learning difficulties, at least for a substantial proportion of young children in the lead up to school entry.

Conclusions

The results of this study suggest that a multi-skill 10 week intervention delivered to four year old children in nursery in two

to three sessions of 15 minutes weekly can be successful in improving the pre-reading skills of children in comparison with a control group receiving only normal nursery schooling. Even those children resistant to remediation improved their skills following a further more targeted intervention over a four week period. We consider that this research has significant implications for educational policy and practice, in the UK and beyond. Guidelines for cost-effective nursery screening and intervention emerging from this study include the administration of short age-normed screening tests designed for this age group, followed by explicit small group teaching of language and motor skills over a short time frame, with further individual targeted intervention for children who do not accelerate. This leads to the possibility of 'inoculating' children against failure, combining the advantages of early teaching with the sheltered environment of the nursery. This should have significant 'knock on' effects, allowing a more rapid pace of teaching in the early school years and reduced incidence of reading failure, leading to beneficial effects throughout the educational system, and, in due course, society.

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"Amazing Shortcomings, Amazing Strengths"

Beginning to Understand the Hidden Talents of Dyslexics

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Editor's note. This concept of giftedness in dyslexia is one that has not yet been widely addressed within the Asia Pacific context. This is despite the recognition given to the mild dyslexia of former prime minister of Singapore, Lee Kuan Yew, a seminal force in government for over 30 years. A search for eminent dyslexics in these areas reveals only the Indian actor, Abhishek Bachchan, and the young dyslexic Malaysian pilot, Captain James Antony Tan, the youngest pilot to fly around the world, with two entries in the Guinness Book of records, who is still only 21. There are undoubtedly many more famous dyslexics who have not yet revealed their difficulties in learning, because of the potential stigma attached. This recognition of the extraordinary strengths of some dyslexics, if they are not too daunted by the difficulties they experience in school, should begin to redress the balance. Above all, identifying and supporting the problem early can reduce the potential impact on self-esteem, allowing dyslexic people to fulfill their potential and make a full contribution to their environment.

Overview of a New Awakening

In recent years, developmental dyslexia is coming to be seen, remarkably, as a significant advantage in an increasing number of fields – often linked to substantial success in design innovation, entrepreneurial business and scientific discovery. As hard as it is for many to believe, it is becoming more and more clear that some dyslexics are capable of envisioning possibilities, seeing patterns and making discoveries that are missed by even the smartest non-dyslexics.

It is also becoming increasingly clear that all of this is because of the dyslexia, not in spite of it. Currently, during a period of

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new awakening, a small number of researchers are finding more evidence that dyslexia does not result from damaged "wiring" in the brain, as many have long believed. Rather, they see an alternative (a different but valuable) "wiring" pattern – one that involves early educational difficulties – but one that provides alternative strengths and capabilities generally not available to non-dyslexic brain structures.

An example of these new perspectives on dyslexia research and practice is found in the recent book *Dyslexic Advantage* by Drs. Brock and Fernette Eide, which asserts: "the brains of individuals with dyslexia aren't defective; they're simply different. These wiring differences often lead to special strengths in processing certain kinds of information, and these strengths typically more than make up for the better-known dyslexic challenges."

"We don't see the reading, spelling, or other academic challenges associated with dyslexia as the result of a 'disorder' or a 'disease.' Instead, we see these challenges as arising from a different pattern of brain organisation – [which predisposes] dyslexic individuals to the development of valuable skills" (Eide & Eide, 2011, xvii).

There are many cases of this paradoxical mix of weaknesses and substantial strengths. It is becoming increasingly apparent that these are not really unusual – and appear to be representative of an important subgroup that needs to be studied in a systematic and rigorous fashion. A good example (to be dealt with at greater length below), is one of the founders of the modern study of molecular biology. He was a classic dyslexic, with the usual reading and writing problems throughout his early education. Yet, as he as he eventually struggled through college and graduate school and progressed into laboratory work, he found that he could predict the results of many experiments. He found that he could use his powerful dyslexic imagination to see interactions at the molecular level – seeing new patterns and developing fundamental insights and new theories (in one instance, twelve years ahead of all others in the field) about the links between the human genetic code and the development of the immune system. Later, a different scientist proved experimentally that he was right and received a Nobel Prize (Tauber & Podolsky, 1997).

The US National Science Foundation has been funding a Harvard-Smithsonian study of when and where dyslexia may be an advantage in doing science, especially within astrophysics (Schneps, 2013). In the UK, the dyslexic head of the Virgin Group explained long ago that his dyslexia had been a motivator in building his group of more than 250 companies as well as giving him a "business edge" (Branson, 1999). In the field of computer graphics and simulation, dyslexic artists, scientists and technologists are often leading innovators (West, 2004, 2009)[1].

A dyslexic professor at Columbia University has written the book, The Great Ocean Conveyer, about how he was able to integrate complex information (in a manner similar to many other dyslexics)

[1] *Note: Some sections from this edition, with other writings, have been modified for inclusion in this paper.*

from extremely diverse sources to understand the way historic changes in ocean currents have led to abrupt climate change in the past. In the preface, he explains, "As a dyslexic, I receive my most valuable information and ideas from what I hear and diagrams I see rather than what I read on the printed page" (Broecker, 2010, ix-x).

A world famous professor of paleontology, dyslexic himself, says that he tries to teach his graduate students how to "think like a dyslexic" so they can see patterns invisible to others, making discoveries long thought impossible. The rest is "just memorization," he says, without significant discovery or true innovation (Horner, 2007)[2]

Very recently, in an especially striking example, the British electronic intelligence agency GCHQ announced publically, "Dyslexia is Britain's secret weapon in the spy war: Top code breakers can crack complex problems because they suffer from the condition. GCHQ bosses say those with the disorder see things in codes others do not. The Cheltenham-based agency has set up a dyslexia support group." One agency official noted that "dyslexia may in other circumstances be regarded as negative – but most people only get to see the full jigsaw picture when it's nearly finished while the dyslexic cryptographists can see what the jigsaw looks like with just two pieces" (Mail Online, July 13, 2013). Long aware of the important contribution of distinctive dyslexic talents (along with other forms of "different thinking"), GCHQ had held its first "Diversity Day" as early as June 2006. However, the agency had rarely been so public about these considerations until they were raised by recent comments from MPs on the Commons Intelligence and Security Committee.

While many are still skeptical, an increasing number of researchers believe that learning from the lives of highly successful dyslexics and visual thinkers can lead to new insights and approaches that will help dyslexics and non-dyslexics alike -- profoundly transforming fundamental ideas about education and work in a time when computer technologies are rapidly turning the world upside down and the established professionals seem to have lost their way. Accordingly, they say it is high time for us to begin to recognize and understand and learn how to deal with these puzzling extremes in talent – the unexpected academic weaknesses that seem often to be associated with special capabilities and success in both life and work. Low level weaknesses should not be allowed to prevent high level accomplishment. Schools, they say, almost never teach or test what dyslexics are good at – but life does.

Early Puzzle

From the time of the earliest researchers (in the 1890s) until Samuel Torrey Orton (in the 1920s) and Norman Geschwind (in the 1980s), the central puzzle of dyslexia has always been the linkage of high ability in some areas with remarkable and unexpected difficulties and disabilities in other areas. For more than a century we have recognized this

[2] *Filmed by NHK cameraman (Tokyo, Japan) on site of dinosaur dig, far northern central Montana on Canadian border, about 9 minutes, July 5, 2007.*

pattern, but have generally focused on only one aspect. With the best of intentions, we have learned much about how to fix the problems that dyslexics experience but we have done almost nothing to develop a deeper understanding of the varied and hard-to-measure talents that many dyslexics possess (Geschwind & Galaburda, 1987).

As we have noted, highly successful dyslexics nearly always say that their accomplishments and special ways of seeing come directly from their dyslexia – not in spite of their dyslexia. More researchers are now saying that we should take them at their word and give credence to what they say. Most professionals in the field have long agreed that talents are important, but eventually they almost always come to focus exclusively on the serious business of reading and academic remediation alone.

In contrast, more and more researchers are feeling a sense of personal responsibility to dyslexics as a group. They feel the need to substantially change the course of what is being done within the field. They believe there is a need to seriously embrace a radical change soon or there will be no change at all – allowing additional generations of dyslexics to suffer needlessly – as well as wasting the distinctive talents that are sorely needed by the larger society and economy as we enter an age of great uncertainty on many fronts. They recognize that we badly need the big picture thinking and original insights that seem to be the signature contributions of the most successful dyslexics. (It is a paradox, among many paradoxes, but it may be that those who would appear, initially, to need the most help are, in time, may be those most likely to be able to help the most.)

Much has changed in recent years that would suggest that these fundamental changes in perspective may be much closer to taking place: a small conference of foundations, researchers and highly successful dyslexic individuals and their families took place in April 2013 – which has built considerable momentum in this direction; the increasing influence of the "positive psychology" movement (Seligman, 1990); efforts to integrate dyslexia research with work psychology research (in the UK and elsewhere); books, articles, blogs and websites devoted to "the dyslexic advantage." (Eide & Eide, 2011)

William J. Dreyer – Case Study of a Dyslexic Discoverer and His Grandson

Sometimes, a longer look at a particular case can indicate the potential of these major reversals in perspective. The passage below is excerpted from the oral history project at the California Institute of Technology in Pasadena. The speaker is the late William J. Dreyer, Ph.D., who is increasingly recognized as one of the major innovators in the early days of the biotech revolution that is now washing over all of us. In September 2007, one of his inventions was placed in the National Museum of Health and Medicine in Washington, D.C. – the first gas-phase automated protein sequencer, which he patented in 1977. The sign over the machine on exhibit reads: "The Automated Gas-Phase Protein Sequencer: William J. Dreyer and the Creation of a

New Technology."

"I knew I was different in the way that I thought, but I didn't realize why I was so dumb at spelling ... and rote memory and arithmetic. The first time I realized how different ... brains could be ... was when I bumped into Jim Olds at a dinner party back in the late sixties. Jim ... was a professor here [at the California Institute of Technology] ... famous for his pleasure center work. A speaker talked about the way we think and compared it to holography. Jim was across the table from me. I said, 'Oh, yes. When I'm inventing an instrument or whatever, I see it in my head and I rotate it and try it out and move the gears. If it doesn't work, I rebuild it in my head.' And he looked at me and said, 'I don't see a thing in my head with my eyes closed. 'We spent the rest of the evening trying to figure out how two professors – both obviously gifted people at Caltech in the Biology Division – could possibly think at all, because we were so different. So then I took this up with Roger Sperry [Nobel Laureate and near lab neighbor] and I realized that I had some amazing shortcomings as well as some amazing gifts" (Caltech, 1999)[3].

A strong visual thinker and in many ways a classic dyslexic, Dreyer developed new ways of thinking about molecular biology. With his powerful dyslexic visual imagination, he could somehow see the molecules interacting with each other. Sometimes he was almost entirely alone. He (with his colleague J. Claude Bennett) advanced new ideas based on new data about how genes recombine themselves to create the immune system. These ideas turned out to be many years ahead of their time.

Most did not like this new theory because it conflicted with the conventional beliefs held by most expects in the field in those years. "It was so counter to the dogma of the time that nobody believed it," his widow, Janet Dreyer, explained (Dreyer, J., 2005). Dreyer's approach also used a form of scientific investigation ("peptide mapping") with which most immunologists were then entirely unfamiliar. "Knowing what we know now pretty much any biologist would look at Bill's data and say that is what it has to mean. But few could understand it then," she noted. However, gradually, they all learned to think the way Dreyer thought. Then, it was obvious that Dreyer (and Bennett) had to be right.

To See What Others Cannot See

In his earlier school days, Dreyer had the usual reading, writing, memory and other academic difficulties experienced by most dyslexics. Throughout his career, he avoided reading and writing whenever possible. But in time, he was able to make it to college and even graduate school – where he developed his own ways of learning and began to find roles that that made use of his strengths while he learned to get help in his areas of weakness.

He joined a study group. The others in the group all took careful notes in the lectures. He took no notes. He just sat there while he listened and observed carefully. Then after the lecture, they provided him with the detailed data, and

[3] *PDF at http://oralhistories.library.caltech.edu/108/. Roger Sperry, mentioned in this quotation, was Caltech Hixon Professor of Psychobiology 1954-1984. Sperry was awarded the Nobel Prize in Physiology or Medicine in 1981.*

he told them what it all meant. "He was giving the big picture and all the major concepts, ..."explained Janet Dreyer. Eventually, surviving a major life-threatening illness made him realize it was time to refocus his life – and then his fascination with laboratory work began to draw him in.

Soon, with his remarkable ability to visualize the molecular interactions (using his dyslexic imagination), the young Bill Dreyer became a star in the laboratory. While in graduate school in Seattle, Washington state, and while working at the National Institutes of Health (NIH) in Bethesda, Maryland, he could tell his professors and colleagues which were the best experiments to do. Somehow he knew how to proceed and where to go in this brand new field of study that came to be known as protein chemistry. He was seeing patterns and connections the others were not seeing. Like many highly successful dyslexics, Dreyer could thrive in the leading edge of a new field. Like so many dyslexics, Dreyer seemed far better suited to creating new knowledge than he was in memorizing old knowledge.

At this time, his professors and section heads would write the grants, get the funding and write the research papers with him and for him based on his ideas and observations. "The money just came. Because he was doing good work, grants would just be there for him," observed Janet Dreyer. He was happy at NIH but eventually (after a previous Caltech offer had been refused) in 1963, Caltech persuaded Dreyer to come to Pasadena as a full professor at the age of 33. Clearly, the value of his pioneering work had been recognized.

However, later, because of the further development of his new and increasingly heretical ideas, William Dreyer could not get funding from academic or foundation sources for inventing his new instruments. His department head would get irate phone calls from professors from other institutions complaining about Dreyer's publications and talks. He gave many talks at the time, making some attendees angry, although others could see the importance of his innovative observations. "He was on the lecture circuit then and he [gave these talks] a lot." Of course, these were not really unproven theories, explained his widow Janet. She pointed out that Dreyer was sure of his ground because he had the data to prove the veracity of his ideas. "It was not merely a hypothesis in that paper, it was real data." However, it was data in a form so new and so alien that almost everyone in the field could not understand what he was talking about. In time, these professors, and all their students, came to see, much later, that William Dreyer had been right all along.

Because he could not get funding from the usual sources, Dreyer went to private companies to manufacture the innovative instruments he had designed and built himself – something quite unusual and discouraged at the time but now wildly popular among universities hoping for a share of large royalty payments. Seeing the potential for his inventions (and their scientific impact) but having a hatred of administration and corporate politics, Dreyer came to be the "idea man" for seven new biotech companies (including Applied Biosystems).

Years later, when Susumu Tonegawa was

awarded a Nobel Prize (Physiology or Medicine, 1987) for work he had done in Switzerland, his innovative sequencing work proved (through experiments that were illegal in the US at the time) that Dreyer and his colleague had been correct in their predictions many years earlier. In the words of two scientific historians of this period: "This experiment marked the point of no return for the domination of the antibody diversity question by nucleotide studies: it was Susumu Tonegawa's final proof of the Dreyer-Bennett V-C translocation hypothesis through the use of restriction enzymes" (Tauber & Podolsky, 1997, 207).

Family weaknesses, Family Strengths

Later in his life, Dreyer taught molecular biology to his grandson who was clever with computers but had been having a very hard time in high school because of his own dyslexia. The grandson went to live with his grandfather. Employing the grandson as a kind of apprentice, Dreyer would start each work day (using a form of applied just-in-time learning) saying something like: "I want you to write this little search program for me today but first let me explain the biology you need to know to do this task." In time, working with Dreyer, the grandson skipped the latter part of high school, most of college, all of graduate school and was doing advanced "post-doc" level work writing computer programs, doing advanced programming developing databases, graphic user interfaces (GUIs), and other tools.

The grandson also used sophisticated scientific information visualization techniques to help link various human traits to sections of the genetic code. In doing this work, he noted that he used his "visual thinking ability to design the architecture of the programs ... visualizing the components in his head, trying it out and fixing what doesn't work, before I write the code – much like my grandfather..." He is not only doing high level work; as Dreyer and others pointed out, the grandson was in fact working at the leading edge – co-authoring peer-reviewed journal articles (King, in Roden, 2005, Hart, 2006). Indeed, one of the grandson's work colleagues only got his own Ph.D. degree (and a required publication) because the grandson was able to write a tutorial and GUI that helped a member of the colleague's required publication review committee better understand the significance of the advanced work done by the colleague (Dreyer, Dreyer & King, 2001-2004)[4].

Much later, after years of post-doc level work without even a high school diploma, the grandson decided it was time to go to college. He chose a university with very challenging standards but also an extremely good system for supporting his dyslexia—which presented continuing problems throughout his four years of study. This happened to be the University of California at Berkeley. In May of 2013, the grandson, Brandon King, graduated in Cognitive Science with honors and distinction.

Brandon's grandfather, William Dreyer, died of cancer in the spring of 2004. One of the enduring passions of his later work had been to try to understand the

[4] *Additional clarifications and further details were provided by Brandon King via email, March 23, 2009, available from Thomas G West.*

relationship between his dyslexia, his visual thinking and the high levels of creativity he had experienced in his own life and work. Dreyer's interest led to his participation in a small conference on visualization technologies, creativity and dyslexia held at the National Library of Medicine in Bethesda, Maryland. This author's second book, Thinking Like Einstein, is dedicated to: "William J. Dreyer, 1928-2004, molecular biologist, strong visual thinker, prescient inventor, instrument maker, who loved to fly high to see what others could not see, frequently alone."

Magnificently Ill-Adapted Engines of Discovery

The story of the life of William Dreyer and his grandson, Brandon King, brings into sharp focus the considerable advantages, in the right setting, of the dyslexic kind of brain – at least of certain variations within the great diversity of dyslexic brains. (Of course, this story also strongly suggests what sometimes might be possible employing nontraditional educational approaches such as apprenticeship or home schooling.) We can see that this kind of brain – seemingly so magnificently ill-adapted to conventional education – can (sometimes) be a powerful engine of insight, innovation and discovery.

This kind of brain may cause many problems in early schooling but it may also, sometimes, raise some individuals rapidly to the top of a new field of knowledge – pushing forward way beyond the many who are conventionally successful students but who find it hard to conceive of anything really new or really important. Perhaps they cannot see through to the novel, unexpected solution because they have learned too well exactly what the teacher wanted them to learn, what was expected on the conventional test. Perhaps they cannot easily unlearn what they have been taught.

In another example, one high-achieving researcher at NIH, with three professional degrees, in law, medicine and pharmacology, once admitted that he was aware of his own limitations, constrained beneath a kind of glass ceiling. He was aware that in spite of all his success and academic accomplishments, he "was not dyslexic enough" to do really original, creative and important work – as he had seen in his dyslexic colleagues. (Personal communication, R.S., March 2000.)

With stories such as these, we can begin to understand that these visual-thinking dyslexics do indeed see the world differently. They think differently. They are not like non-dyslexics. They are not like each other. Often, they seem to "see things that others do not see." (This same phrase – with almost exactly the same words – reoccurs with striking frequency in many different and unconnected settings.) Yet these same individuals have great difficulty with things that are easy for almost everyone else – especially at the lower levels of education. In schools, they are constantly tested on what they are not good at – almost by definition.

Why are they never tested, we should ask, in the areas where (some and perhaps many) have enormous talent and can make major contributions in their later life and work? Can teachers and

school psychologists believe that this is possible? It is hoped that some of the stories offered here will have created a new vision of what is possible. But this new vision may also require the development of new tests and measures -- ones quite different from conventional academically-oriented measures – but perhaps ones that are better suited to the new realities of life and work, suited for the visual-thinking dyslexics but also suited for many non-dyslexics as well.

To succeed with such extremely mixed abilities, as these individuals often do, one needs to have a deep reservoir of confidence and fortitude to carry on in spite of the judgments of others that you are, in fact, really slow and lazy and stupid. To maintain the required drive, determination and sense of mission in the face of almost constant early failure and humiliation is often nothing short of miraculous. It would appear that only a comparatively small number survive these early days with enough confidence and drive to press on, against all odds, to find success in some area of special knowledge, deep understanding and passionate interest. We need to better understand the nature of this kind of success and the remarkable individuals who seem able to find their way around so many obstacles, seeking an area where they are at home with their work, often performing at very high levels of proficiency and productivity.

Those of us who are trying to understand and to help dyslexics (along with others more or less like them) must come to see that conventional academic remediation is only part of the job – and not the most interesting or important part. We need to seek ways to help dyslexics find and develop their own talents, large or small, so that they cannot be beaten down – hiding their distinctive talents along with their disabilities. One of the best ways – perhaps the only really effective way – to do this is to study the lives and work of highly successful dyslexics (in some detail and in all their great diversity) – to allow other dyslexics to see what can be done as well as showing how it can be done.

The story of Bill Dreyer and his grandson shows clearly the mixed problems and great potential of dyslexic individuals and dyslexic families in a most modern, scientifically-sophisticated and technologically-advanced context. The talents that many dyslexics exhibit are powerful and valuable assets (frequently hidden and misunderstood) in a rapidly changing world. These individuals may appear to be slow and backward, but in many cases they are way ahead of nearly everyone around them, those who are mostly blind to what visual thinking dyslexics can do and what they can contribute.

Over the years, more and more dyslexic individuals have become aware of their own special talents as they confront their long-hidden weaknesses and humiliations. Many are finally coming to understand the positive aspects of their own mixed abilities well enough to give themselves permission to talk about and think about things they no longer need to see as only failures and weaknesses to be hidden and denied. They have discovered that it does not go away just because you pretend it is not there.

Fathers are realizing that they cannot

drive it out of their sons by ever more rigid discipline. Rather, they are learning that it is best to confront it, face on, with the new realization that there are hidden talents to be acknowledged (and used) as well as fears that will increasingly fade away in the clear light of day.

Learning to see the positive side can be powerful indeed. Of course, there is still a great deal of work to be done, but it can be focused on increasing strengths rather than decreasing weaknesses. It is urgent at this time to outline the kinds of things that need to be done – to take seriously, at long last, the varied talents and considerable strengths of dyslexics. The time is right. The time is late. The time is long overdue. Those on the front lines – the teachers, tutors, parents, advocates and school psychologists–those who have cared the most, those who have been able to understand when no one else did--unfortunately, they have often done less than they could have done because they have attended to only half of the job. They have too often focused on fixing the problems – and have totally ignored the development of talents. This should change – and we hope that it will change soon.

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Biographical Sketch

Thomas G. West is the author of *In the Mind's Eye: Creative Visual Thinkers, Gifted Dyslexics and the Rise of Visual Technologies* (Prometheus Books), selected as one of the "best of the best" for the year by the American Library Association (one of only 13 books in their broad psychology, psychiatry and neuroscience category).

In the Mind's Eye was published in Japanese translation in as *Geniuses Who Hated School*. A Chinese translation was published in 2004 and a Korean translation was released in 2011. West's second book is *Thinking Like Einstein*: Returning to *Our Visual Roots with the Emerging Revolution in Computer Information Visualization*. Dyslexic himself, Mr. West has been invited to provide presentations for scientific, medical, art, design, computer and business groups in the U.S. and overseas, including groups in Australia, Canada, New Zealand, Hong Kong, Taiwan, Dubai and twelve European countries. Mr. West is associated, as board advisor or board member, with several organizations, including the Krasnow Institute for Advanced Study at George Mason University, the Dyslexic Advantage organization, the Siena School and the Wye River Upper School, among others.

Recent invited conference lectures or keynotes have included: Magdalen College Oxford, Harvard and MIT, University of California at Berkeley, University of Malta, University of Trieste, the Arts Dyslexia Trust in London and an education conference in Dubai, United Arab Emirates. Early in 2013, West gave a talk on creative visual thinking, computer graphic information visualization and dyslexia at Pixar Animation Studios in Emeryville, California – and presented a Director's Colloquium on a similar topic for scientists and staff of NASA Ames Research Center (at Moffett Field in California's Silicon Valley).

Postscript

Important alternative research trends and perspectives have been becoming more apparent recently. The Dyslexic Advantage organization (with which this writer is associated) has recently formulated a strategy for research progress built around the following series of observations:

It is increasingly clear that dyslexic individuals do not only differ from non-dyslexics in the ways they process written language. Rather, they differ in the ways they process almost all kinds of information. Consequently, researchers now see that they will need to study more than reading and writing.

In addition, dyslexic individuals are seen to share common strengths as well as areas of difficulty – and these strengths usually involve brain functions unrelated to reading. Indeed, the strengths of dyslexics provide the reason that there are so many dyslexic individuals in the human population – that is, the dyslexic wiring pattern in the brain has been selected over long periods of time as a favorable trait and this provides the basis for achieving such high prevalence.

Increasingly, researchers are becoming more aware that dyslexia is a late-blooming profile. The strengths of dyslexics are often more apparent later in development than the strengths of many non-dyslexics. Consequently, because these strengths are more apparent in adults than children – when the nervous system is fully matured – it is now seen as important to study dyslexic adults, including those who are excelling in their lives and work as well as those who continue to have difficulties.

Another important observation within the Dyslexic Advantage perspective is that it may be inherently difficult to measure the things that many dyslexics are good at. Dyslexic individuals often excel in complex high-level cognitive tasks. Consequently, researchers believe they need to develop more creative research approaches and testing methods capable of measuring these high-level skills and talents. These researchers are learning to re-examine dyslexic children in light of what they have learned about the mature adult dyslexic brain. This way, they hope to be able to better understand the true nature and significance of what they observe in the earlier stages of development.

To emphasize this last point, the Dyslexic Advantage organization has chosen to adopt the image of the butterfly as the institutional logo and symbol – believing that one can only see what the dyslexic brain is "trying to become" by considering its mature form. If one were to study caterpillars only, one would never guess that this fat, ugly worm with so many legs is ultimately destined to fly high and far on wings of iridescent beauty. (Personal communications, Dyslexic Advantage, October 2013.)

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Mathematical Difficulties in Singapore: A Case Study Approach

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Introduction

The assessment and identification of children with learning difficulties in mathematics in Singapore has not been much researched and discussed in journal articles. The majority of studies in the international literature are based on case studies, which is the approach adopted here with 10 cases in the Singaporean context.

Case study cannot hope to confirm or disconfirm any new causal theories (Robson 1993), but it can contribute to an earlier stage of scientific enquiry, of collecting and classifying relevant examples, and so illustrate directly what difficulties children and their parents and teachers are facing. It may through analysis throw some fresh light on assessment, differential diagnosis, curriculum and intervention effects and thus contribute to a broad understanding of learning difficulties in maths and how children might be helped to learn.

The Background:

Learning difficulties in mathematics are sometimes called Mathematical Learning Disabilities (MLD), or just MD, and sometimes developmental dyscalculia, or simply dyscalculia. The former is preferred in the USA, while the latter is more common in the UK, where the government defines it as "..a condition that affects the ability to acquire arithmetic skills. Dyscalculic learners may have difficulty understanding simple number concepts, lack an intuitive grasp of numbers, and have problems learning number facts and procedures. Even if they produce a correct answer or use a correct method, they may do so mechanically and without confidence." (DES, 2001) In the USA, MD falls under the Specific Learning Disabilities" umbrella. DSM-IV (American Psychiatric Association, 1994) defines it with the following diagnostic criteria:

a. Mathematical ability, as measured by individually administered

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standardised tests, is substantially below that expected given the person's chronological age, measured intelligence and age-appropriate education.

b. The disturbance in Criterion A significantly interferes with academic achievement or activities of daily living that require mathematical ability.

c. If a sensory deficit is present, the difficulties in mathematical ability are in excess of those usually associated with it.

The concept of dyscalculia is quite controversial, with claims that this neurological condition is found in only around 2% of the population, and that the remainder reflect learning difficulties in maths (Peard, 2010). In Singapore, however, it is most common to use the term "dyscalculia", but the assessment and identification of children with MD is relatively uncommon, and there are no government guidelines on terminology or criteria for assessment other than where difficulties "in mental calculation" (MOE, 2011) co-occur with dyslexia, at present.

On the other hand, Singapore is renowned for the success it has achieved in mathematics education, especially with its top ranking in the third TIMSS study (Kaur, 2009). There is a considerable body of literature on mathematical education in Singapore (see Mathematics Education: The Singapore Journey, 2009), which includes concerns with difficulties in learning many aspects of maths, and with some particular difficulties (notably maths and test anxiety). However, this literature does not mention dyscalculia and refers only very briefly to remedial and special education for children with MD. This disjunction between mathematics educators (e.g. Royer, 2003) and learning disability and special education researchers (e.g. Hulme & Snowling, 2009, Pennington, 2009, Chinn, 2012) may in fact be international. There are few references in the books and articles of either group to the other.

Singapore provides an important crossroads where maths education and a concern to help children who have difficulty meet. Singapore is now one of the most prosperous and developed countries on Earth, and it sets high standards and has high aspirations for its young people's education. It prides itself on being rigorously meritocratic, and selects schools and streams within them through a national exam at 12 (Primary School Leaving Examination, PSLE) testing English, Maths, Science and Mother-Tongue. Parents provide very high levels of support to children, and most students attend some additional tuition beside their regular schooling. At the same time awareness of the nature of learning difficulties is growing, especially in literacy. English is one the country's official languages and education is almost entirely provided in English. Singapore has one of the largest Dyslexia Associations in the world (DAS, see www.das.org.sg), and awareness of the nature and value of skilled identification and support for children with literacy difficulties has grown steadily. Tuition in maths has always been sought by parents and awareness of the need to consider dyscalculia or MD alongside dyslexia is now beginning to grow. Singapore DAS has begun to offer maths tuition in addition to literacy.

Two new books by well established teacher-researchers have provided excellent materials and guidance for the assessment of children with MD in the UK: Chinn has written much on mathematical learning difficulties and dyslexia (Chinn and Ashcroft, 1993); his new book "More Trouble with Maths' (2012) provides detailed materials and guidance on assessment, and Emerson and Babtie have produced a similar book, "The Dyscalculia Assessment" (2010).

Chinn mainly talks about "maths difficulties" rather than "dyscalculia'. He believes a range of standard cognitive assessment tools, including WISC-IV, are helpful in understanding the difficulties of individual children. He has developed several specific maths assessment tools to clarify children's' strengths and difficulties in maths learning and performance. These include the 15 Minute Test, a general calculation skills test, brief timed tests of addition, subtraction, multiplication and division skills, an Anxiety test to explore children feelings about maths and the maths lesson, and a brief word-problems test. He also provides extensive guidance on informal observation work with children whose mathematical learning presents concerns. Emerson and Babtie also offer a broad framework for assessment, with more detailed and systematic observation and curriculum led assessment, without standardised testing.

There is some firm evidence of co-morbidities between MD and other learning disorders, based on a shared genetic underpin for maths and reading of 0.74 (van Daal, van der Leij and Ader, 2013). There are indications that more children may have both MD and dyslexia than dyslexia alone (UK, Lewis Hitch and Walker,1994), and maths difficulties are typical in some syndromes (Turner's, Fragile X, Pennington, 2009). In general, associations with other disorders such as ADHD and Specific Language Impairment (SLI) cannot straightforwardly be predicted. This appears to imply that when an explanation of a children's mathematical and other difficulties are being sought, multiple diagnoses should be the default.

Maths in Singapore is different from other countries especially because of the emphasis at the primary stage on solving word problems; a high proportion of PSLE maths involves these problems. They involve both very careful reading and understanding of the questions (which are often multi-step), and the use of a specific "bar modelling" technique for solving them, leaving algebraic approaches to the first secondary year. So Singapore children have arguably to be able to analyse logically complex statements and represent them in pictorial form in order to solve these problems. A particularly striking example from a Primary 5 paper (children aged 10-11) was:

> *"Bin has $30 more than Ron. Wei has 4/3 of the average of what Ron and Bin have. The average amount of money that Bin and Wei have is 1½ of Ron's money. How much money does Wei have?"*

The importance of word problems of this type means that assessment has to include work on Singapore maths. UK or US problems are not generally in the same league.

In literacy, the importance of rigorously researched "interventions" (that is, additional teaching or support that supplements mainstream class teaching) has been strongly advocated, especially in the USA (eg Torgeson, 2001) but equally in the UK (Hulme, 2011). Interventions, in this sense, are not much yet available in the MD literature. Much of the mathematics education literature is about teaching approaches, but this is nearly always mainstream class-teaching. Some general principles for helping students have been suggested by Chinn and others (eg Miles & Miles, 1992): use of concrete materials, teaching to particular learning styles ("inchworms vs grasshoppers"), making verbally explicit statements about mathematical processes and supporting calculation inefficiency with various aids, but their approaches have not been tested experimentally. Interventions for MD in Singapore must necessarily be speculative at this stage, it seems.

It is widely agreed that causal explanations for MD/dyscalculia are not yet available, but there appear to be two main positions: that there may be a single ultimate cause (eg Butterworth, 1999, numerosity) or that there may be a range of separable difficulties (including numerosity, verbal reasoning, working memory, long-term memory, spatial ability). Hulme and Snowling (2009) suggest that a single cause may apply to "pure" dyscalculia while multiple causes may affect children with co-morbid dyslexia and dyscalculia. Geary suggests three subtypes, a procedural type who have difficulty learning arithmetical strategies linked to verbal memory weakness, a semantic memory type with difficulties retrieving facts from long-term memory and a visuo-spatial subtype, who have difficulty representing number spatially (Geary, 2004). This lack of consensus about causality has implications for psycho-educational assessment.

Very few studies of dycalculia or maths difficulties in Asia have been published. In 2002, Ramma and Gowramma report an extensive study suggesting how children might be identified within Indian Primary schools; they found around 5.5 to 6% of children were dyscalculic. More recently, Chan and Tang (2013) examined differences between students with dyscalculia and those who were not dyscalculic but who had "low numeracy", using two different scores from the Butterworth "Dyscalculia Screener as the basis for the distinction. They used a series of tasks exploring the differences between symbolic and non-symbolic tasks with their Grade 1 children in Hong Kong, and suggested that the Butterworth dyscalculics were satisfactory at symbolic tasks, but not non-symbolic tasks, while the non-dyscalculics showed the opposite pattern.

In the absence of agreement about labels, clearly established diagnostic criteria, assessment techniques, information about associations with a wider range of specific difficulties, interventions, causal explanations and evidence about the Singapore context, this background analysis suggested that a case study approach (Butler et al, 2005, Peard, 2010) in Singapore would be informative as far as these issues are concerned.

Research Aims

The aims were to consider what are the most helpful components of an assessment of maths difficulties, what diagnostic criteria and labels might be appropriate, and how co-occurring conditions might affect diagnosis; what effects the Singapore context might have, what interventions and accommodations might be most relevant, and what models of the causes of maths difficulties might best guide assessment.

Methodology

This study examines the findings of a series of psycho-educational assessments of children to shed some light on the research questions. By its nature a case-study does not attempt to prove particular causal explanations of MD. It aims instead to suggest which factors may be most worth further investigation, and to sketch the landscape beneath the terminological and procedural jungle of assessment and labelling.

Data are presented from two series of cases involving MD:

1. Singaporean children assessed because of primary concern about mathematical learning difficulties or dyscalculia;
2. Children from International Schools either in Singapore or in the SE Asia region about whose mathematical learning there was concern alongside concern about literacy or general learning difficulties.

The main focus of this paper is the first group, but the second group provide some additional contrasts and raise some further questions beyond the scope of the main series.

The first series is grouped by age, because the stages of education in Singapore seem to bring particular challenges, hence different kinds of referral seem to be presented at different ages.

The children were not seen for research purposes, but to provide an assessment report at their parents' request, prior to further decisions about additional tuition, other help or exam accommodations. The first series includes all children seen because of MD, while the second includes all children seen following more general concerns where MD seemed a significant issue. The children were all seen between October 2011 and July 2012 at the Dyslexia Association of Singapore (DAS).

DAS's main role is to provide assessment and regular tuition in small classes for Singaporean children with dyslexia. A small team of specialist psychologists assesses children for dyslexia and write reports which include a diagnosis and recommendations for teaching including additional tuition, most often via DAS classes. Children are not specifically assessed for other developmental disabilities by this team, although they may suggest that further assessment for other difficulties such as MD is advisable. Since August 2011, DAS has also offered an assessment and tuition service to the nearly 2 million expatriates living in Singapore and to the large numbers living in the region. A new International

team was formed including two experienced educational psychologists from the UK, a senior Speech and Language Therapist and recently an Occupational Therapist, together with a team of qualified teachers and experienced tutors. The author was part of the International team and as it happened was the only psychologist wanting to offer assessments of mathematical difficulties. Thus the cases reported were from referrals from Singaporean parents wanting an initial assessment only of MD, or where there had been previous assessment which did not focus on MD, or from expatriate parents living in Singapore or the SE Asia region wanting a general assessment including a significant maths concern.

DAS began to offer classes for maths as well as literacy difficulties in 2011 and demand has increased rapidly. Further psychology assessment is not required to access the weekly maths classes; parental request is sufficient, so the first series presented here did not carry with them issues and concerns about entry criteria for classes as such. However, the Singapore Ministry of Education expects children entering DAS literacy classes to have a dyslexia diagnosis and so there is background expectation that assessment at DAS may lead to a diagnostic label. Usually parents request a "dyscalculia assessment" rather than an investigation of mathematical learning difficulties, probably because of this expectation. In discussion about their referrals, parents were told that a dyscalculia diagnosis was a possible outcome but this should not be expected; the main purpose was to investigate possible mathematical learning difficulties (MD).

Details of all assessments have been anonymized and parental agreement to present the data in this way has been obtained.

The Cases:

1. Young children with possible MD:

Two children ages 6½ to 7½ in Primary 1 provide interesting similarities and contrasts. Andrew had been assessed already by an experienced and qualified psychologist and this assessment had found he was of about average general ability, articulate but with some weaknesses in reading comprehension, with an attention difficulty severe enough to be described as ADHD. He was attending Kumon classes but had made no progress on double-digit subtraction for some weeks, and his parents were getting worried. Ben had also been seen by a psychologist, and had at first seemed autistic, but this impression had altered and he was also now seen as having a mild attention difficulty. He seemed badly stuck on dealing with numbers above 9, in spite of a real facility in using a Chinese abacus.

Key background ability data is detailed in table 1.

These boys were thus quite similar in background abilities: Ben had a significant previously diagnosed language difficulty (which was assessed as more severe on CELF-IV), both were quick and somewhat impulsive, and both had satisfactory word reading, thus ruling out the possibility that they couldn't read the questions in maths. Ben had impressive spatial ability on BAS-III, but

the closest comparison on WISC suggested good but not outstanding ability in Andrew (estimated visual processing 111). Andrew was a confident and quite articulate personality, while Ben was shy and rather withdrawn in assessment and in class.

Attainment data (standard scores) and data from Butterworth's Dyscalculia Screener is detailed in Table 2.

The attainment and screener data thus diverged: although both were better at calculations than problems, Andrew was much stronger at both. The two Singapore maths samples were constructed to involve very similar numbers and the same problem format except for one giving 4 alternatives and the other only expecting an answer. Andrew did better on the multi-choice format, probably because it forced him to consider whether his own answer was satisfactory; he was consistent in the types of question he got right across the two forms. He was very quick and accurate on the screener, and this was consistent with a good score on the WIAT fluency tests. Ben seemed at first to be responding satisfactorily to the screener but the outcome was effectively: "don't

Table 1: Background Cognitive and Reading using standard score data for Grade 1 children

Name	Age	Grade	Cognitive Ability	Verbal Ability	Non-verbal Ability	Spatial Ability
Andrew	6:11	1	106 W*	92 Li	115 D	-
Ben	6:09	1	107 B	81 B 73 Li	115 B	123 B

Name	Age	Working Memory	Processing Speed	Other disabilities	Word reading	Reading Comp'n
Andrew	6:11	87 D	136 D-SIP	ADHD	105 W*	90 W*
Ben	6:09	95 B	113 B-SIP	Lang, mild attention	99 W*	66 LC*

[W= Wechsler tests, B = British Ability Scales III, D = Differential Ability Scales II, Li = Listening Skills Test, LC = Listening Comprehension from WIAT, * = from previous assessment information]

Table 2: Maths attainments and dyscalculia screening data for Grade 1 children:

Name	Math Problem	Number Operations	Fluency	Mental Arith	Screener: Addition 0-9	Screener: Multiplication 0-9	Screener: Reaction Time
Andrew	97	124	147	105	9	9	8
Ben	78*	105*	95	-	2	-	-

Name	Screener: Dot Enumeration	Screener: Number Stroop	Screener: Diagnosis	Singapore maths: multi-choice /10	Singapore maths: direct answer /10	Singapore maths: direct answer /10
Andrew	9	9	Not dyscalculic	6/10	3/10	3/10
Ben	2	2	Random responding, cannot diagnose	3/10	1/10	1/10

[All attainments data from Wechsler tests, WIATII or WIATIII, * = from previous assessment, all screener data from Butterworth's Dyscalculia Screener]

know" because he made too many "random" responses; his calculations were very unreliable once he moved above 10; and although he got 3/10 right on Singapore multi-choice, a close look at his responses (which were not consistent between the two forms) suggested a random responding element here too.

There was no opportunity for direct observation of Andrew doing maths, but papers from his school suggested scores of over 50% on tests, with a possible pattern showing longer word problems causing problems, especially comparisons between quantities, and some specific skills (such as picture partition problems) consistently causing trouble. With Ben, some informal observation showed he could reliably identify numbers to 99, estimate small quantities accurately using bricks, and use Dienes base 10 materials with support to represent larger numbers accurately.

The conclusions were thus different. Both had some mild working memory weakness, perhaps associated with attention difficulties, and in different circumstances could go too fast, especially Andrew. Both had some difficulty understanding word problems, associated with weaker language ability especially Ben, but when he could use

problem, and thus to difficulty understanding vital new concepts, especially place value at the P1 stage. Both had become a little doubtful of their abilities, with Ben much more generally unsure and Andrew especially stuck on double digit subtraction. Andrew did not seem to lack number sense; Ben's number sense was not so clear, but he seemed very stuck on the meaning of tens and units. Both needed help. In Ben's case the best way to convey his need was to suggest that he was "dyscalculic at present", in line with the Singaporean Ministry of Education expectation that disabilities may be overcome, in spite of the usual expectation that a "diagnosis" is unlikely to alter over time. In other words, he needed recognition and help and with help might overcome this difficulty in time. In Andrew's case, his impulsivity seemed to be the main factor affecting maths learning, so an additional label did not seem necessary.

2. A Primary 3 child with severe doubts about his maths abilities

Data on Carl is a little more restricted, because he was visibly unhappy to work in the first session and wanted to put his head on the desk and say nothing in the second. He had shown some difficulties with reading in Kindergarten but had eventually caught up, and then in P1 shown signs of reluctance to attend school. He was quiet and anxious. In P3 the maths had become harder and he

was showing signs of real difficulty with word problems and to be quite slow to learn number facts and multiplication bonds. He passed P2 maths (over 50%) but so far in P3 was doing badly (latest exam 21%).

Background ability data is detailed in Table 3.

Carl's overall ability was at the low end of average, and this seemed to be mainly because of less strong verbal ability. But he was very good at recalling sequences of digits (on BAS-II). Unfortunately his reluctance to engage in the second session prevented further direct investigation of these vital areas, but there was an important difference in his literacy: while word reading was excellent, comprehension was only average. This seemed to link to the verbal ability weakness on BAS-III. He was quick on SIP, and working memory did not seem to be a problem in his case.

Attainment data and data from Butterworth's Dyscalculia Screener is detailed in Table 4.

As expected from the verbal and reading comprehension results, Carl did much less well on Math Problem Solving; he made some calculation slips and mistakes on problems, and reached his understanding limit on fractions and rotation of shapes. He was better at pure calculations, again with some slips on subtraction and weaknesses in times tables. Fluency was surprisingly low. Although the Butterworth Screener said dyscalculia was unlikely, his weakest area was Dot Enumeration, the most pure test of the number sense theory, and this seemed to make sense of his weak fluency and reported difficulty getting number facts and bonds to automaticity.

Table 3: Background Cognitive Ability data for a P3 child:

Name	Age	Grade	Cognitive Ability	Verbal Ability	Non-verbal Ability	Spatial Ability
Carl	8:06	3	86 B	74 B	94 B	98 B

Name	Age	Working Memory	Processing Speed	Other disabilities	Word reading	Reading Comp'n
Carl	8:06	109 B	130 B-SIP	Mild school refusal	130 W	102 W

[W= Wechsler tests, B = British Ability Scales III, D = Differential Ability Scales II, Li = Listening Skills Test, LC = Listening Comprehension from WIAT, * =from previous assessment information]

Table 4: Maths attainment data and dyscalculia screening data for a primary 3 child;

Name	Math Problem	Number Operations	Fluency	Mental Arith	Screener: Addition 0-9	Screener: Multiplication
Carl	95	109	86	-	4	-

Screener: Reaction Time 0-9	Screener: Dot Enumeration 0-9	Screener: Number Stroop 0-9	Screener: Diagnosis
5	3	6	Dyscalculia "not likely"

[All attainments data from Wechsler tests, WIATII or WIATIII, * = from previous assessment, all screener data from Butterworth's Dyscalculia Screener]

concrete apparatus or see the problem, he was stronger. Andrew's attainments on normative and Singapore maths were average or above, while Ben's were particularly weak on word problems, in which much Singapore maths is framed. Andrew's difficulty seemed most strongly associated with his impulsivity (ADHD), while Ben's was more closely linked to a primary language comprehension

The second session began using WISC Block Design as a warm-up, because it is essentially non-verbal, and seemed likely to be an activity Carl would succeed at. He showed considerable uncertainty about some of the problems, and it became possible to prompt him to "try changing this a little and see if that helps"; it did and so it was possible to say to him that he can solve problems. He then tried some Singapore maths, and although he was unwilling to verbalize it was clear that he often went off on the wrong track. Dienes apparatus was used to make the problem concrete and visible, and although close support was necessary, he seemed to be able to reach solutions using the apparatus. It was possible to conclude optimistically that he can learn to deal with problems if he receives help to see what they mean.
The conclusion was that he shows "some indications of dyscalculic difficulties, which are likely to become more severe (because of the cumulative nature of the maths curriculum) unless action is taken to improve his skills and regain confidence in himself as a maths learner." This intermediate conclusion seemed justified because problem solving is only a little weaker than average at present, and the likely explanation (limited verbal ability linked to general anxiety and specific doubt about himself as a maths learner) implies greater plasticity.

3. Two children approaching PSLE

The Primary School Leaving Examination (PSLE) is very important indeed in Singapore education: it functions as the Eleven Plus used to in most of England, to sort children into streams and form the basis for all secondary education admissions. Unlike the 11+, it mainly comprises tests of attainments in all three core subjects, English, Maths and Science.

The two children, Daphne 11¾ in P6 and Ernest, just 11 in P5, had experienced difficulties for some time, Daphne probably since P2 when other girls in her class called her "stupid" and other names in maths lessons, Ernest for about 2 years as his scores and confidence began to dip. In both cases parents wanted to know if there was a serious problem or did they just need more or better tuition.

Background ability data is detailed in Table 5.

The children differed in their cognitive profiles: Daphne had overall average ability with slightly better verbal skills, while Ernest was above average overall, strong non-verbally with about average verbal ability. Working memory was fair to good in both cases, and this was somewhat surprising in Ernest, whose parents had noted he still tended to use his fingers while calculating. Daphne was particularly quick in handling visual symbols. Reading was not a concern for either child.

In both cases, actual maths attainments on US tests were good or above average, and in a small sample of Singapore maths problems there was also reasonable consistency and attainments. Ernest did seem to have relatively slow maths fluency, and he was observed to use fingers and sub-vocalize sometimes when doing calculations. This

Table 5: Background ability data (in standard scores) for two children approaching PSLE

Name	Age	Grade	Cognitive Ability	Verbal Ability	Non-verbal Ability	Spatial Ability
Daphne	11:08	6	103 W	114 W	97 W	-
Ernest	11:00	5	120 D*	106 D*	130 D*	115 D*

Name	Age	Working Memory	Processing Speed	Other disabilities	Word reading	Reading Comp'n
Daphne	11:08	109 W	125 W	None	-	105
Ernest	11:00	116 W	118 D-SIP*	None	113 D*	115 W*

[W= Wechsler tests, B = British Ability Scales III, D = Differential Ability Scales II, Li = Listening Skills Test, LC = Listening Comprehension from WIAT, * =from previous assessment information]

Table 6: Maths attainments and dyscalculia screening data for pre-PSLE children:

Name	Math Problem	Number Operations	Fluency	Mental Arith	Screener: Addition 0-9	Screener: Multiplication 0-9
Daphne	112	124		105	7	8
Ernest	123	138	99	110	5	6

Screener: Reaction Time	Screener: Dot Enumeration	Screener: Number Stroop	Screener: Diagnosis	Singapore maths: multi-choice /10	Singapore maths: direct answer /10
6	6	9	Not dyscalculic	6	7
6	6	7	Not dyscalculic	6	6

[All attainments data from Wechsler tests, WIATII or WIATIII, * = from previous assessment, all screener data from Butterworth's Dyscalculia Screener]

was perhaps associated with slightly lower scores on some of the Butterworth tests. Both children did present concerns to their parents and teachers but these seemed to be a result of not understanding some key topics very well (especially ratio, fractions and percentage). Daphne was not very keen to return for a second session but she did; she needed to say she didn't know why she was coming because she didn't feel there was anything wrong with her. This was an extremely helpful question, because I was able to reply that there wasn't anything wrong. She did, however, need to focus on some topics in maths as part of tuition. Similarly Ernest needed to improve his understanding but he did not seem to have any developmental disorder.

4. Three children at the early secondary stage

Two girls, Fanny and Grace, were both in their first secondary year, and neither was dyslexic (although earlier Fanny had been described as having Irlen Syndrome and ADD), but Ho, a boy, had recently graduated from several years of tuition in a dyslexia programme, and was in the second secondary year. All three had expressed unhappiness with maths over time – they were finding it quite difficult; Fanny was supposed to receive some extra classes in school (but she tended to avoid them), Grace had just started with a new tutor, which seemed promising, while Ho was not having any maths tuition currently.

Their background data is detailed in Table 6:

Grace presented as bright and quick. Her verbal ability was higher than Fanny's, while her spatial ability was quite low. Fanny seemed to present more as a low average ability child, and her attention difficulty was said to be very evident in class. They were also different in the kind of motivation they seemed to have: Grace was very determined, wanting to learn how she could find better ways to handle the maths, while Fanny seemed to be accepting the adults' view of her as ADD; she commented that she "just hated maths, anyway". Ho was good average in most areas, with somewhat stronger non-verbal than verbal abilities. Both Ho and Fanny were good word readers with weaker comprehension skills. I didn't test Grace in those areas.

In retrospect, the assessments of both Fanny and Ho would have benefited from including the Dyscalculia Screener, because both young people had problems with calculation skills; in their cases, assessment was not mainly focused on maths, while for Grace this was the focus. Grace was in fact usually very good at calculations, and was also taking a lot of initiative to find ways to tackle problems. She felt quite strongly that she had a problem but was tackling it vigorously. I considered that her efforts needed some recognition so I felt it best, after listing her considerable strengths, to say that she also had some difficulties with maths, including her weak spatial ability, the lower scores on the pure number sense tests of the screener, her high anxiety and sometimes quickness combined with rigidity of thinking style which hindered her problem solving style, and these amounted to "dyscalculic features". Fanny's difficulties were

Table 5: Background ability data (in standard scores) for two children approaching PSLE

Name	Age	Grade	Cognitive Ability	Verbal Ability	Non-verbal Ability	Spatial Ability
Fanny	13:0 yrs	Sec1	84B	94B	82B	82B
Grace	12:07 yrs	Sec1	93B	109B	95B	78B
Ho	13:08 yrs	Sec2	113W	106W	115W	-

Name	Age	Working Memory	Processing Speed	Other disabilities	Word reading	Reading Comp'n
Fanny	13:0 yrs	121B	108B	ADD Irlen Syndrome	117	101
Grace	12:07 yrs	113B	145B	None	-	-
Ho	13:08 yrs	110W	109W	dyslexia	109	91

[W= Wechsler tests, B = British Ability Scales III, D = Differential Ability Scales II, Li = Listening Skills Test, LC = Listening Comprehension from WIAT, * =from previous assessment information]

Table 6: Maths attainments and dyscalculia screening data for early secondary children:

Name	Math Problem	Number Operations	Fluency	Mental Arith	Screener: Addition 0-9	Screener: Multiplication 0-9
Fanny	103	96	90	90	-	-
Grace	122	124	134	-	8	7
Ho	108	90	-	105	=	-

Screener: Reaction Time	Screener: Dot Enumeration	Screener: Number Stroop	Screener: Diagnosis	Singapore maths: multi-choice /10	Singapore maths: direct answer /10
-	-	-	-	4/4	¼
3	4	5	No	10/10 at P6	7/10 at P6
-	-	-	-	-	-

[All attainments data from Wechsler tests, WIATII or WIATIII, * = from previous assessment, all screener data from Butterworth's Dyscalculia Screener]

perhaps understandable as part of a more general learning difficulty, while Ho had particular difficulties with calculations, and particular concepts seemed not to have been properly grasped; he also seemed to have become discouraged about learning maths, and his motivation to improve was not strong.

5. Two children at the College stage:

Isobel and Julie were both 17 but in rather different situations. Isobel had left school about a year previously and done a vocational course at a college; she hadn't much enjoyed it and wanted to return to college to do other courses, but was worried she would need a pass in maths or obtain an exemption. Julie had taken the prestigious Junior College route and so had to study maths even though she had always found it hard. She was now studying maths A level, and finding she was spending longer working on the maths than on other subjects, while only just scraping through, in spite of the close support of a personal tutor.

Background data on these young women is detailed in Table 7.

Their cognitive ability profiles are not very different, both having very strong verbal abilities, and both less good non-verbal abilities. Indeed, the difference for Isobel was very marked (51 points between verbal and spatial abilities). Isobel also had lower working memory and processing speed. Julie varied in her speed of doing things, while Isobel was mostly quite a slow worker. Both were

Table 7: Background ability data (using standard scores) for two young people at college;

Name	Age	Grade	Cognitive Ability	Verbal Ability	Non-verbal Ability	Spatial Ability
Isobel	17:02 yrs	College	Range too great	129D	84D	78D
Julie	17:07 yrs	College	110D	121D	106D	100D

Name	Age	Working Memory	Processing Speed	Other disabilities	Word reading	Reading Comp'n
Isobel	17:02 yrs	80D	73D	No	102W	107W
Julie	17:07 yrs	108D	102D	No	-	117G

[W= Wechsler tests, B = British Ability Scales III, D = Differential Ability Scales II, Li = Listening Skills Test, LC = Listening Comprehension from WIAT, G = Gort Silent Reading Test, * =from previous assessment information]

satisfactory to good at reading.

Maths and screening test data is detailed in Table 8.

Julie was able to achieve at above average levels on the American maths tests I had available; her speed on the fluency tests was also good, and she achieved good scores on the dyscalculia screener at a 14 year old level (there was no screener available for a 17 year old at that time). I was not able to see her current maths performance on A level materials. But her descriptions of her struggles over time with maths, including at present, were authentic: she had to work very hard to be able to solve the problems she was given and she did so by learning a procedure and following it very assiduously, with some help from her tutor; she didn't do well in class tests but when she had time for prolonged revision she was just able to pass. It seemed to me that her uneven abilities (good verbal but average non-verbal and spatial) together with some other difficulties she described (eg recognizing faces, working out routes and directions) could best be seen as a "mild non-verbal learning disorder", and that this was a good enough explanation of her maths learning difficulty.

Isobel had been ungraded in her final school exams in maths. Her current skills were very weak, even allowing for the year when she had not been studying any maths. She also impressed as someone who was struggling with difficulties, which

Table 8: Maths attainments and dyscalculia screening data for 2 young people attending college

Name	Math Problem	Number Operations	Fluency	Mental Arith	Screener: Addition 0-9	Screener: Multiplication 0-9
Isobel	77	81	72	-	-	-
Julie	120	119	113	110	6	9

Screener: Reaction Time	Screener: Dot Enumeration	Screener: Number Stroop	Screener: Diagnosis	Singapore maths: multi-choice /10	Singapore maths: direct answer /10
-	-	-	-	Unable to do any Singapore Sec 3 maths problems	
2	6	9	Unlikely	A level maths problems not readily available	

[All attainments data from Wechsler tests, WIATII or WIATIII, * = from previous assessment, all screener data from Butterworth's Dyscalculia Screener]

in her case seemed more severe. She tried to do some maths problems at a 14 year old level, and had to bring them back saying she couldn't do any. It seemed as though the bigger disparity between verbal and non-verbal abilities and her quite slow processing speed and weaker working memory combined to make learning maths almost impossible beyond about a 9 year old level. I suggested her difficulties should be described emphatically as "severe dyscalculia."

6. Other children where maths difficulties were part of a more general assessment:

These children add to the range of patterns of abilities and needs which are considered in forming judgements about MD/dyscalculia. An important group of students, Ken (10), Patrick (17) and Richard (18) were within or on the borderline of children with moderate general learning difficulties. Could they therefore be described as also MD/dyscalculic? In fact two of them had been previously assessed and had been described as dyslexic, so it seemed illogical not to also describe them as MD/dyscalculic when their maths difficulty was as great as their literacy weakness. Since Stanovich's strong argument against discrepancy assessment for dyslexia (Stanovich 1991), I have argued that even children with general LD can also have a specific difficulty with reading – if not, they may be denied exam accommodations and teaching help which will benefit them. Although the case against discrepancy assessment for MD/dyscalculia has not been made, it seems that the arguments for special weaknesses in MD/dyscalculia, such as number sense, working memory, verbal reasoning, and spatial ability are essentially similar to the argument that Stanovich put forward, namely that IQ is a poor predictor of word reading and so a discrepancy between it and reading was irrelevant to reading achievement. So it seemed both educationally appropriate and logical to allow that they might have MD/dyscalculia as well as dyslexia. In Richard's case, he had developed a strong dislike of maths, and his problem solving was weak, but calculation skills were about average, so I felt it would be unhelpful to label him as dyscalculic, in case this functioned as an excuse not to learn or as an excuse not to teach him. He might in good hands at the college level do better if he really needed maths skills.

Marcos was in the early secondary stage and probably had struggled because of a combination of second language and auditory processing difficulties. He was now doing better in school, and although he felt maths was still his weakest area, I felt he too would be best seen as capable of overcoming his difficulties, especially with a focus on the language of maths problems; in fact his WIAT-III maths scores were all close to average.
I gave nuanced judgements on several others. Lianne was dyslexic, and her score on WIAT maths problems was low; on the Butterworth screener she got 3's and 4's but the programme said she wasn't dyscalculic. I felt she did have particular problems with working memory (low WMI on WISC-IV but also low mental arithmetic), and with processing speed, nor did she have much confidence in her own maths ability. So I suggested she

had "mild dyscalculia". Oliver had quite severe dyslexia but he was verbally very able and was making quite good progress educationally; maths was still quite a problem for him. His weakness on the fluency tests and a big difference between good verbal and lower non-verbal abilities (30 points) justified describing him as having "dyscalculic features". Similarly Vernon had been described as dyslexic, but he was also a long term intermittent school refuser who probably also had general anxiety difficulties associated with Asperger Syndrome. He did not believe he was able to do maths, but in fact did some calculations and types of problems reasonably well. His working memory was also a weakness. I felt it would help him to be seen as having some dyscalculic features, so drawing attention to his learning difference but hopefully not preventing sustained effort.

I suggested that previous assessment had been wrong about Wendy, who had been described as dyslexic, dysgraphic and dyscalculic on the basis of a discrepancy between the performance IQ of a very old version of WISC on which she had achieved a very high score. In fact her spelling was still weak but reading and maths were at average levels, so I argued that she should not been seen as dyscalculic. In 3 of four other cases, I suggested that the children were dyscalculic because of a combinations of working memory, verbal comprehension, fluency and self-doubt issues. In one other case, where a 9 year old boy was clearly dyslexic but was doing somewhat better in maths, I felt there was not a clear enough case for a dyscalculia label, although he was below average on the WIAT-III tests.

Discussion: implications of these cases for research, analysis and assessment.

1. Psycho-educational assessment of MD:

Recent books (Chinn, 2012; Henderson, 2012) have provided a helpful overview and much specific material for MD assessment. The cases reported here were a mix of specific MD assessments and more general assessments, and so time available for assessment undoubtedly played some part. More thorough assessment is possible if there is a specific maths focus. Especially this means making time for informal observation and exploration, as both Chinn and Henderson advocate.

Both WISC-IV and BAS-III (or DAS-II) have strengths and weaknesses for MD assessment; if language is a potential issue, then WISC seems to offer more, and working memory is also more straightforwardly assessed in WISC. If spatial or other aspects of non-verbal abilities are more salient, then BAS or DAS may be more useful, and they are usually quicker.

When using maths tests in Singapore, it is essential to go beyond US or UK normed material because most children in Singapore will do well on it. Material which takes account of both the Singapore curriculum and its strong focus on word problems is necessary. This may not be the case in other places which are more similar to the countries where maths assessments are normed, although there remains a need for efficient assessments

of word problems and for ways of assessing maths vocabulary knowledge. The computer based screener from Butterworth certainly adds to the picture in ways that pencil and paper or oral assessment cannot. As the cases above illustrate, sometimes the evidence from other sources goes contrary to the screener results, and so the programme verdict has to be questioned. In all cases it helps to "triangulate" results.

Given the possible importance of working memory, there may be a need for measures of it which do not rely on digit tests. There may also be a need for tests of verbal and non-verbal reasoning which explicitly do involve numerical and other quantitative domains. There may be, more generally, some significant longer-term benefit of consistency in being able to scale strengths and difficulties across all relevant psycho-educational areas (especially attention and motivation), given the significance now accorded co-morbidities.

2. Diagnostic criteria and labels:

Diagnostic criteria set by researchers, teachers, special education administrators and exam boards all serve somewhat different purposes. It seems extremely likely from recent research that a continuum rather than a categorical system reflects best the reality of children's differing needs, but even researchers often need to say that children either are or are not dyscalculic (Hulme & Snowling, 2009). Similarly, they also prefer to exclude children with more general LD. The levels of difficulty at which exam accommodations can be justified and additional interventions are funded are important and are likely to become more regulated as MD/ dyscalculia becomes better studied and identified. At present, my approach, which takes account of levels of difficulty on US norms but also seeks direct observation of maths work on the Singapore curriculum, enables me occasionally to say that a young person has some degree of dyscalculia even if they can do US tests fairly well; this is partly because Singapore word problems are very different and substantially harder in most cases. I am thus elevating a judgement about a child's subjective difficulty above the information from normed assessment. Ideally I would like this option to continue to be available, but I expect it will be removed in time. There is of course a danger that psychologists will advocate exam accommodations for children who are perceived in a broader educational context as undeserving. However, it is essential that normed materials satisfactorily and fully encompass the range of learning challenges that children face, and that the norms can be justified in each country.

I have always considered that labels can be but are not always socially and educationally helpful. The balance needs to be weighed, usually with the parents. If a school is unable to adapt its teaching and provide appropriate support and exam accommodations, then a label may mean to some teachers that a child will be too difficult to teach, and so may be unhelpful. Or the child may reject the suggestion that they have a "condition". But sometimes the label serves as a way of explaining a potentially or actually depressing learning difficulty which can

be dealt with better if it is set out openly.

The broader context also makes a difference: in Singapore, a diagnosis is required for dyslexia, if exam accommodations or publicly funded help are needed, so there is an expectation that nothing short of medical model labelling is significant. And most children can and do receive additional tuition, so a recommendation for additional help is normal, whatever the level of difficulty.

In spite of the pressures for labelling, it may be helpful to retain some scaling of difficulties. From the cases presented, an appropriate three-step scale is "mathematical learning difficulties", "dyscalculic features" and for the most severe cases "dyscalculia"; this may be closer to current research thinking (eg Dehaene, 2011, p275-6) than qualifiers such as mild, moderate or severe dyscalculia.

3. Other disabilities and diagnosis

This is likely to remain quite a difficult issue to regulate. Recent developments in research thinking (eg Hulme & Snowling, 2009) emphasize a new sense that many or even the majority of children have more than one disability. How psychologists and other professionals should explain multiple difficulties is far from clear: can a pre-existing language difficulty/disorder, general learning difficulty or attention deficit account fully for a child's maths difficulties? The cases illustrate both some situations where prior difficulties seem to provide sufficient explanation and others where they do not. Just where the lines should be drawn is not very clear, and might not be clearer even if each child were simultaneously assessed by a multi-disciplinary team (which is sometimes suggested as a way of handling complex cases).

An assessment ideally brings together information from multiple sources, and provides a coherent explanation of what difficulties the child experiences. Occam's Razor sometimes needs to cut through lists of overlapping difficulties, which are often intended to show a child needs much extra help. There should ideally be no rule that says how many disabilities a child can have, or even which is primary, but the assessment is most effective if the explanation makes sense, and leads to the right kinds of help in the right order.

4. Curriculum issues

The main cases reported here are of Singaporean young people, and the special qualities of Singapore maths demonstrably make a difference to assessment and diagnosis. By extension, the features of any curriculum and teaching strategy should also be considered relevant. Arguably, maths in Singapore is difficult enough to justify quite a lot more assessments of MD and hence more additional teaching and accommodations. There is a need for assessment materials which make clearer the child's response to a particular curriculum. In the Singapore case at the primary stage, this especially means word problems, assessed in both multi-choice and simple answer formats.

5. Interventions and Accommodations

This paper is intended to summarize 10

cases, with some further information about another 12, so there has been little room for details of interventions and accommodations. Intervention research using modern forms (eg Randomized Controlled Trials) in MD is quite limited at present (Hulme & Snowling, 2009), so we mainly rely on the experience of practitioners (eg Miles & Miles, 1992, Chinn etc).

- In all cases there have been elements of addressing the child's own views of their strengths and weaknesses, and this is certainly a theme from experienced practitioners.

- A second major theme has been using concrete materials where symbolic processes and understanding seems weak, before returning to the use of symbols alone. Concrete materials have also been recommended where the focus is on general weaknesses in language and understanding of maths concepts and procedures: this might be called the "multi-sensory teaching" strategy for MD, because a key aim is to enlarge and make more reliable verbally mediated understanding of maths.

- In the absence of a maths vocabulary test, it has not been possible to make this a specific recommendation, but teaching the language of maths (as realized in a particular curriculum) is also a clear need in many cases.

- In some cases, where working memory is a weakness, traditional support strategies (using lists and visual cues, short explanations, rehearsal etc) have been suggested, and for older children direct computer based interventions (such as Cogmed, Gray et al, 2012) have also been mentioned.

- Although calculation speed and efficiency has sometimes been a significant concern, no specific interventions for older children have been suggested. For younger children there are some promising computer based interventions. I am not aware of any research studies of the use the abacus, which could provide another possible approach.

- Generally, there do not seem to be any well-known interventions to support young people whose spatial and non-verbal reasoning abilities seem to be the main cause for the MD. The main recommendation is thus to work around the weakness, expecting the child to require a single, consistent teaching method using verbally explicit concepts and procedures, avoiding alternative ways of tackling the problem.

- Finally for some children who are seen as having some mild MD, they need remediation in particular maths topics and some teaching about study skills, especially estimating and checking solutions.

The main accommodation is extra time, which is particularly important where there is an element of anxiety. For one of the college-level students, it was suggested that she be exempted from a maths qualification for further courses, but I understand colleges are resistant to this. The use of a calculator for sections of

exam papers where they are not normally allowed has also been recommended, but whether this is acceptable is not yet clear. It is possible to envisage wider accommodations (by analogy with the use of a reader for a dyslexic student) such as an exam format in which maths problems are presented as pure calculations. It is unlikely that this would be acceptable, and students are more likely to be channelled into types of exam or tiers which are less challenging.

6. Models of Mathematical Difficulties

This paper is not intended to provide evidence to bear on the underlying cognitive explanations of MD. The theory of MD is in any case not yet well developed (Hulme and Snowling, 2009, Dehaene 2011). However, assessment of children's mathematical learning must have some theoretical underpinning and direction – the psychologist needs to have some ideas of what to look for if a coherent and plausible explanation of a learning difficulty is being sought. The results from 10 case studies suggest a shortlist of possible weaknesses:

- Verbal reasoning skills are likely to have a significant impact on mathematics learning, especially where word problems are prominent in the curriculum;

- Non-verbal (especially spatial) reasoning is also likely to be important;
- Working memory is important, as is speed, but not necessarily the same processing speed measures relevant in literacy. The measurement of WM through Digit Span seems on the face of it problematic, because it is relies on speed of recall of digit symbols.

- Impulsivity and the ability to plan consciously (part of Executive Functioning) is probably very important but is not easy to separate out from other cognitive processes, because these processes are so pervasive.

- Numerosity is obviously relevant but is not easy to discriminate from understanding and calculation skills with increasing age.

- Literacy skills need to be checked carefully.

- Acquired maths skills themselves and especially how complete and reliable the children's understanding of them are vital.

- There are probably links between some or all of these areas, which will mean ultimately that some are seen as primary and others as secondary. Intervention research will also show that some weaknesses can be remediated more effectively than others, perhaps more at particular ages or stages.

The most significant conclusion here is therefore that at present a wide range of possible weaknesses need to be considered – there is no obvious "magic bullet" in helping children with MD. But of course, their current maths skills are where a problem usually first becomes evident. Detailed and systematic analysis of their maths skills and attitudes will remain necessary, even if we do find a

magic bullet for MD.

Conclusions

This study suggests that in a relatively young field, such as the scientific study of children's mathematical learning difficulties, that case study may have a number of roles to play.

It may suggest where current assessment materials and techniques are adequate (eg broad verbal and non-verbal reasoning tests) and where there are gaps (eg specific quantitative reasoning tests in both verbal and non-verbal domains, and mathematical vocabulary measures).

Individual child case studies necessarily use but also ask questions about labels and criteria. A collection of case studies, as in this paper, thus enables some generalization about the implications for individual children and for educational systems as wholes for particular ways to set criteria and to use continua or diagnostic labels.

Current understanding of the range and interactivity of different developmental disorders clearly has a major implication for research. The hypothesis of very commonly occurring co-morbidities (such as dyslexia and MD) calls for significant research interest in this phenomenon. But educational assessment and teaching practice are also affected by the co-occurrence of learning difficulties. The conclusion suggested here is that multiple diagnoses are to be preferred if they make sense and if common histories and effects on learning can be made clear.
The importance of a particular educational context is well illustrated by considering cases of mathematical difficulties in Singapore, I suggest, because of the generally high standards and expectation upon children, and because of some special features of Singapore maths education. Comparisons with other curricula and contexts may be rewarding.

This paper has only mentioned interventions briefly, with no evidence on their effectiveness. However, it is likely that case study can also contribute to the understanding and selection of the most promising interventions for children with MD.

There are perhaps two possibilities as far as the ultimate understanding of the origins of MD: a single cause (such as numerosity) or multiple causes. This paper could not expect to shed light on this difficult research issue. However, it seems likely that as children develop a relatively wide set of abilities needs to be considered when seeking to understand MD in particular cases. Further case study may then perhaps refine which factors or abilities appear most relevant at different ages, so that researchers can profitably focus their attention in the most enlightening ways, and thus clarify whether one or many factors or pathways are involved.

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DYSLEXIA ASSOCIATION OF SINGAPORE (DAS)

Our Mission: Helping Dyslexic People Achieve

Our Goal: To build a world class organisation dedicated to helping dyslexic people and those with specific learning differences in Singapore and reaching out to the Region

Our Aims:

- To put quality first in delivering a comprehensive and effective professional service for dyslexic people and those with specific learning differences on a not-for profit basis.
- To provide an assessment service for individuals at risk of having dyslexia and/or specific learning differences.
- To provide educational programmes and other support services for individuals with dyslexia and/or specific learning differences.
- To raise public and professional awareness of the nature and incidence of dyslexia and specific learning differences.
- To enable others (teachers, parents and professionals) to help dyslexic individuals and those with specific learning differences.
- To assist and elicit financial and other support for people with dyslexia, those with specific learning differences and their families.
- To promote and carry out local research into dyslexia, specific learning differences and to disseminate results.
- To network with other organisations in Singapore and internationally to bring best practices to the DAS and Singapore.

DAS as a Social Enterprise

- We provide high-quality, professional, innovative and client-focused solutions to create and sustain services for the dyslexic community in Singapore and the region.
- We operate as a financially viable and cost-effective business which at the same time ensures that no dyslexic person is unable to access our services because they cannot afford it.
- We generate social returns on our investments through the development of a dynamic, motivated team of highly qualified and experienced professionals.
- We have a heightened sense of accountability to stakeholders through our professional management team.

Registered in 1991, the Dyslexia Association of Singapore (DAS) is today a vibrant voluntary welfare organisation with over 225 full-time staff who provide a wide array of services for dyslexics not only in Singapore but in the region. DAS Specialist Psychologists conduct assessment and diagnosis for preschool students to adults. DAS Educational Therapists, Speech and Language Therapists and an Occupational Therapist provide support for over 2,600 preschool, primary and secondary school students in 11 venues all over Singapore. Increasingly, DAS provides support for dyslexics who also suffer from other Specific Learning Differences such as ADHD, Dyspraxia, Dyscalculia and Non-verbal Learning Differences.

The DAS Academy is a Private Education Institution (PEI) registered with the Council for Private Education (CPE). It is a wholly-owned subsidiary of the Dyslexia Association of Singapore (DAS). Like DAS, the Academy is also a registered charity with the Commissioner of Charities. DAS Academy delivers a wide range of workshops and courses including a Master of Arts in Special Educational Needs. DAS Academy provides the bridge that links professionals, caregivers and people with special needs.

Asia Pacific Journal of Developmental Differences

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Contents

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