Australian Journal of Education and Developmental Psychology Vol. 6, 2006, pp 39-49

Brief Report

Computer-based phonological skills training for primary students with mild to moderate dyslexia – a pilot study.

John M. Blythe[1]
University of New South Wales

ABSTRACT

This pilot study investigated the efficacy of *Phonics Alive 2: The Sound Blender,* a computer-based phonological skills training program, delivered with both at-home and at-school components over a 10-week period, as a potential treatment of phonological dyslexia. **Participants** were 20 dyslexic primary students with an average delay of 13 months on a word reading task; 11 months on a reading comprehension task, and 25 months on a pseudoword decoding task. **Results** indicated significant main and interaction effects for the treatment group, particularly on reading comprehension and pseudoword decoding measures. **Discussion** of results includes the potential advantages of computer-based treatment programs which involve the home and the school in cooperative ways.

INTRODUCTION

Converging evidence from the fields of psychology, neurology and education is producing a picture of dyslexia as a neurobiologically based, phonological processing deficit that can be corrected (or at least improved) by specific kinds and intensities of remediation (Lyon, Shaywitz, & Shaywitz 2003; Ramus et al., 2003; Shaywitz 2003; Vellutino, Fletcher, Snowling, & Scanlon, 2004). In particular, explicit and systematic instruction in phonemic awareness (noticing, identifying and manipulating the sounds of spoken language), and phonics (noticing how letters and letter-blends represent these sounds), has proven effective in increasing reading fluency, comprehension, real word and non-word reading, oral reading and spelling skills among dyslexic children (Blachman, Tangel, Ball, Black & McGraw 1999; Brunsdon, Hannan, Nickels & Coltheart 2002; Gillon & Dodd, 1997; Lyon 1998), with gains typically maintained at 12 month follow-up (Blachman et al., 2004; Gillon 2002).

In recent years, the principles of phonemic training have been married with advances in computer assisted learning to produce a variety of commercially available phonics training programs. Despite the widespread use of such programs by schools and households, very few studies exist demonstrating the efficacy of these interventions. A notable exception from the United States has been efficacy studies demonstrating significant gains for below average readers using *Daisy Quest* and *Daisy's Castle*, research-based computer software providing instruction and practice in phonemic awareness (rhyme identification), and phonological decoding (segmenting and blending) (Barker & Torgesen, 1995; Mitchell & Fox, 2001).

[1] John M. Blythe
School of Psychology
The University of New South Wales
PO Box 1, Kensington, NSW, 2033, Australia.
Email: john.blythe@childpsychology.biz

ISSN 1446-5442 Web site: http://www.newcastle.edu.au/group/ajedp/

Aims of the present research:

The present study aimed to assess the efficacy of *Phonics Alive! 2: The Sound Blender* (Nelson & Hall, 1999), a commercially available, computer-based phonics training program widely used by Australian primary schools and households[2]. A secondary aim was to assess whether a combined at-home / at-school treatment, driven by the student and monitored by a parent, would yield a sufficient condition for gains in key reading skills.

Hypotheses:

According to theoretical accounts of the role of phonological awareness in reading development, some reading sub-skills were expected to show more immediate improvement with brief phonics training than others (Lyon, 1998; Shaywitz, 2003). Specifically, a large and significant gain in phonological decoding skill was expected (Mitchell & Fox, 2001). Significant gain in sight word recognition was not expected as word recognition has been shown to rely on a well developed word form area in the brain and this area is hypothesised to develop *after* word analysis skills improve at the level of phonological coding (Shaywitz, 2003). Moderate benefit was expected for reading comprehension, because improvement in word analysis skills, when aided by context, should improve general comprehension, even in the absence of improvement at the whole-word recognition level (Engen & Hoien, 2002).

METHOD

Participants:

Participants were recruited from a medium sized private primary school in western Sydney. Ethical approval was granted by the school principal and the UNSW School of Psychology Human Research Ethics Committee. Thirty five students (grades 1 to 6) receiving weekly, group-based remedial reading instruction at the school were referred to the study by the support teacher. Families of referred students attended an information evening which detailed the treatment program and the nature and extent of parental involvement. Of the 35 referrals, 15 male and 5 female students in grades 1 to 5 (mean age = 101.35 months, SD 17.58 months), were subsequently identified as being of average or higher general intelligence (mean FSIQ-2 = 100.15, SD = 9.38), free from other co-morbid specific learning disorders, and from a family who consented to participate in the research.

Materials:

Cognitive Screening: In order to control for the possible confounding effect of global cognitive impairment, the Wechsler Abbreviated Scale of Intelligence (WASI) was administered to the 35 referred students (Wechsler, 1999). This is consistent with the notion of dyslexia as a reading impairment that is “unexpected in relation to other cognitive abilities” (Lyon et al., 2003). The FSIQ-2 index score of the WASI is derived by administering the Matrix Reasoning and Vocabulary subtests of the WISC-III yielding a brief FSIQ with an average reliability coefficient of 0.96 and a correlation coefficient with the WISC-III FSIQ of $r = 0.81$. (Wechsler, 1999). Fifteen students with general ability levels below the 20^{th} percentile (FSIQ-2 < 90) were removed from the sample.

Tests of Reading Achievement: Participants were assessed for current reading ability using items from the Wechsler Individual Achievement Test, second edition (WIAT-II), (Wechsler, 2002).

- The *Reading Comprehension Index* provided a measure of general reading ability. It is produced by combining the standardised scores of each of the following reading subtests.
- The *Word Reading* subtest provided a measure of sight word reading, with participants reading aloud from a graded word-list (or identifying letters and letter blends for K-1).

[2] The publisher advised more than 20,000 copies of the program had been sold in Australia since its development.

- The *Reading Comprehension* subtest provided a measure of textual comprehension. Graded tasks included reading narrative passages (either aloud or silently) then answering comprehension questions.
- The *Pseudoword Decoding* subtest provided a measure of the student's ability to apply phonetic decoding skills. Students read aloud from a list of graded nonsense words designed to mimic the phonetic structure of words in the English language.

At-home Progress Chart: Feedback on adherence to the treatment protocol, the number of modules attempted per week and student results for each module were gathered by means of an at-home progress chart, completed by a parent or guardian.

Procedure:

After initial screening, participants were randomly assigned to either a control or treatment condition. Control participants continued to receive their school-based reading instruction (both in-class and at a weekly remedial group with the support teacher). Children in the treatment group also continued with their school-based instruction but in addition, commenced the 10-week computer-based training program in phonemic awareness and decoding skills.

The Treatment Program:

Phonics Alive! 2: The Sound Blender (version 1.2) is a commercially available phonological skills training program, originally developed in consultation with the New South Wales Department of Schools Education, Australia (Nelson & Hall, 1999). The program consists of 12 modules which systematically build skills in phoneme awareness, phoneme-grapheme correspondence, sound and letter blending, and speed of processing. All forms of diagraphs, diphthongs, silent letters and suffixes are explored and explained. Each module takes approximately 15 minutes to complete. Student results are automatically generated for each component of a module with an overall percentage of correct responses displayed at module completion.

Students were instructed to repeat each module at-home until a mastery level of 90% correct responses was achieved for that module. Upon mastery of a module, students were asked to complete the review worksheets (included in the school version of the program) for that module. Students were free to progress to the next module at their own pace, provided they had reached the mastery level and completed the review worksheets for the previous module.

The at-school treatment component consisted of a weekly 30-minute, one-on-one session with the researcher in which the student's progress was assessed by reviewing their at-home progress chart and their completed worksheets (5 minutes), and observing the student complete the current module on an at-school computer (to verify mastery). The remaining time was spent playing a 'nonsense word game'. This consisted of using lower case alphabet cards to isolate any consonants and vowels the student was having difficulty identifying by its sound. The researcher and student then took turns using these letters to make 'nonsense words' which the other had to pronounce. For example, the consonants 'b', 'd' and 'l' might be selected and placed face-up in front of the student, then the student would turn over one vowel card, for example 'u', and use it to make new pseudowords with the selected consonants (such as: bū, dū, ūb, ūd, dūb, būb, blūd, dūlb). Over time the number of consonants and vowels were increased according to the child's age and developmental level (samples of words produced by the children included: blap, plid, gruck, basif, dullup, groosh, pillsid, dindle). Students were provided with a set of alphabet cards and were encouraged to play this game at-home with a parent or older sibling.

RESULTS

At-home progress

Parent reports indicated an average of 3.6 computer modules were attempted per child, per week, with all children remaining compliant throughout the 10-week period. Eight out of ten children completed all twelve modules, with the two youngest completing through to module 10.

Tests of Reading Achievement

Preliminary Analysis

The mean age and intelligence levels (WASI-2 index scores) for the treatment and control groups are detailed in Table 1 along with the pre-test scores on the main reading measures. There were no significant pre-test differences between groups on any of these variables.

Table 1. Observed Pre-test Means, Standard Deviations, and Independent Samples t-test for equality of means**.**

Measure	Group	N	Mean	SD	t	Sig.
Age (in months)	Control	10	102.90	16.980	.385	.704
	Treatment	10	99.8	18.937		
WASi-2	Control	10	101.50	9.846	.634	.534
(index score)	Treatment	10	98.80	9.199		
Reading Composite	Control	10	88.00	7.64	.354	.728
(standard score)	Treatment	10	86.80	7.52		
Word Reading	Control	10	90.50	10.233	.332	.744
(standard score)	Treatment	10	89.00	9.967		
Word Reading	Control	10	-11.9	10.969	.376	.712
(delay in months)	Treatment	10	-13.8	11.641		
Reading Comprehension	Control	10	93.00	8.969	.512	.615
(standard score)	Treatment	10	90.90	9.386		
Reading Comprehension	Control	10	-8.30	12.047	1.045	.310
(delay in months)	Treatment	10	-13.8	11.487		
Pseudoword Decoding	Control	10	87.80	7.857	-.061	.952
(standard score)	Treatment	10	88.00	6.700		
Pseudoword Decoding	Control	10	-24.7	15.019	.110	.913
(delay in months)	Treatment	10	-25.4	13.335		

Mean standard scores for the general reading measure (Reading Composite Index), and the reading sub-test measures, (Word Reading, Reading Comprehension and Pseudoword Decoding) before and after treatment, are depicted in Figures 1 to 4. Reading delay in months, an alternate measure of the sub-test variables is depicted in Figures 5-7.

Figure 1: Reading Composite Index (Standard Scores)

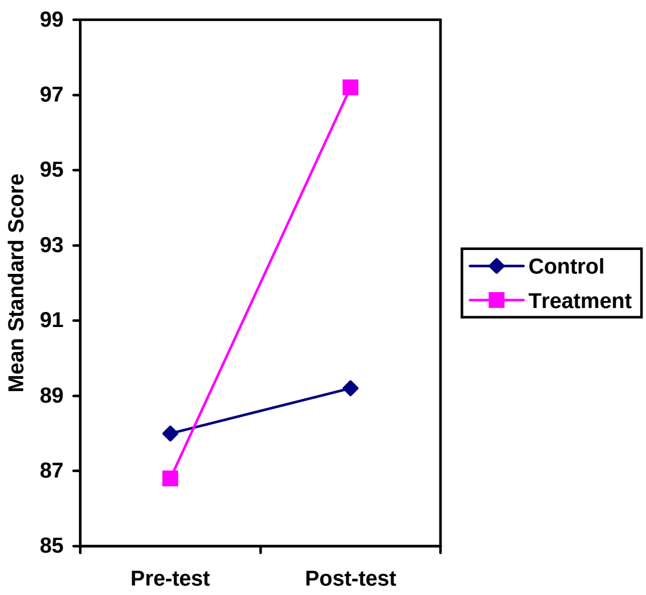
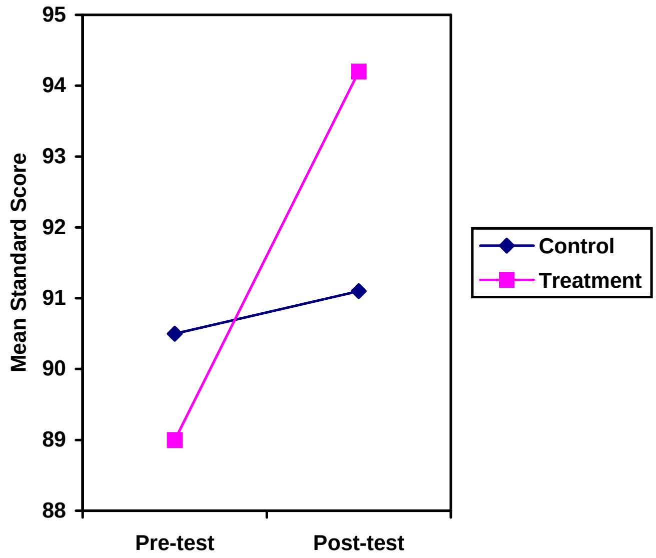


Figure 2: Word Reading Task (Standard Scores)



To test the general hypothesis that treatment would lead to a significant improvement in general reading ability (as represented by the Reading Composite Index), pre and post scores were analysed using a 2 (group) by 2 (pre/post) repeated measures ANOVA. There was a significant main effect over time ($F(1,18) = 46.22$, $p < 0.001$) but as indicated by a significant interaction ($F(1,18) = 29.08$, $p < 0.001$), this effect differed for the two groups. As can be seen in Figure 1, the treatment group improved on post-treatment scores to a greater extent than did the control group. Despite this, an examination of confidence intervals for cell means revealed that there were no significant differences between groups at post-treatment.

To test the specific hypothesis that treatment would produce a significant increase in performance for each of the reading sub-tests (Word Reading, Reading Comprehension, and Pseudoword Decoding), data for each reading sub-test were also analysed using a 2 (group) by 2 (pre/post) repeated measures ANOVA.

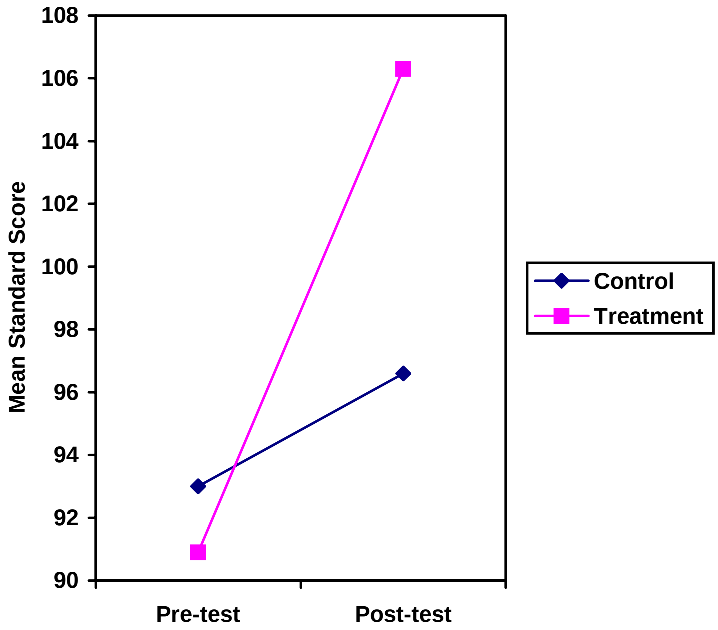
Word Reading

There was a significant main effect over time ($F(1,18) = 10.51$, $p = 0.005$) and a significant group by time interaction, indicating that the treatment effect differed for the two groups ($F(1,18) = 6.613$, $p = 0.019$). As can be seen in Figure 2, the treatment group appeared to achieve higher scores at post-treatment relative to the control group. Despite this, follow-up comparisons based on Bonferoni adjusted 95% confidence intervals failed to indicate a significant difference over time for the treatment group, or between groups at post-treatment. Thus the treatment effects on Word Reading in this small sample appeared to be in the hypothesised direction, but not significantly so.

Reading Comprehension

Once again there was a significant main effect across time ($F(1,18) = 31.22$, $p < 0.001$), and a significant interaction ($F(1,18) = 12.04$, $p = 0.003$. Follow-up comparisons based on Bonferoni adjusted 95% confidence intervals indicated that this was primarily due to the fact that post-treatment scores in the treatment group were significantly higher than at pre-treatment. This was not the case for the control group. Despite this, there was no significant difference between groups at post-test.

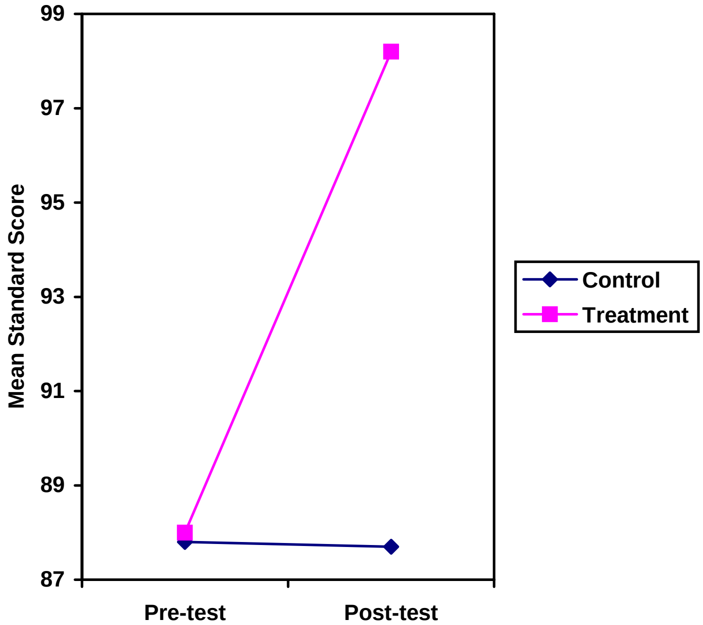
Figure 3: Reading Comprehension Task (Standard Scores)



Pseudoword Decoding

As with the first two sub-tests there was a significant within group effect ($F(1,18) = 24.647$, $p < 0.001$) and a significant group by time interaction ($F(1,18) = 25.632$, $p = 0.001$). In this case the treatment effect for the experimental group was apparent although 95% confidence intervals revealed that pre/post confidence intervals overlapped by 0.59% of one standard score. Once again, there were no significant differences between the two groups at post-test.

Figure 4: Pseudoword Decoding (Standard scores)



The alternate measure of a delay in months (compared to the WIAT-II age-matched norms) revealed the extent of gains made by the treatment condition in terms of 'catching-up' to their non reading impaired peers. As predicted, word reading skills did not increase significantly for either condition with the control group gaining 0.4 months and the treatment group gaining 3.8 months (Figure 5). However, Reading Comprehension showed a gain of 22.4 months, compared to the control group who gained 4.4 months (Figure 6). The greatest relative increase was observed for the Pseudoword Decoding task in which the treatment condition gained an average 20.2 months, compared to the control condition which remained completely static (Figure 7).

Figure 5: Word reading delay

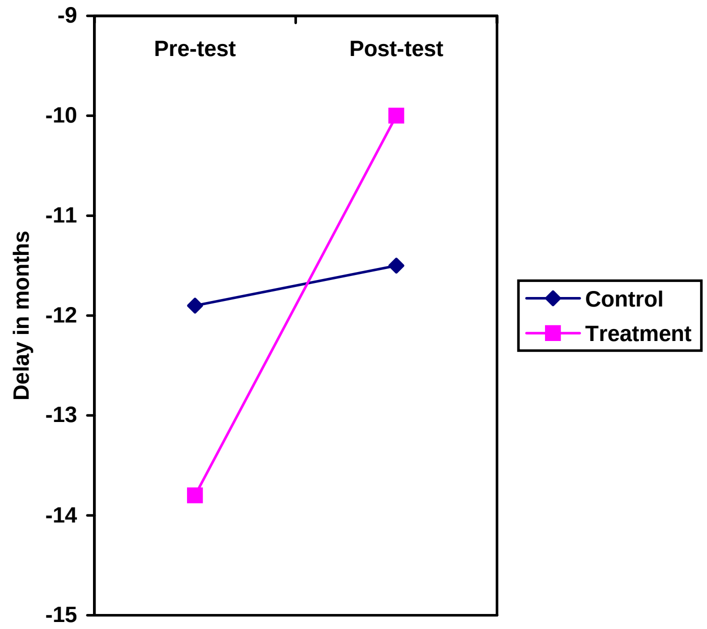


Figure 6: Reading Comprehension Delay

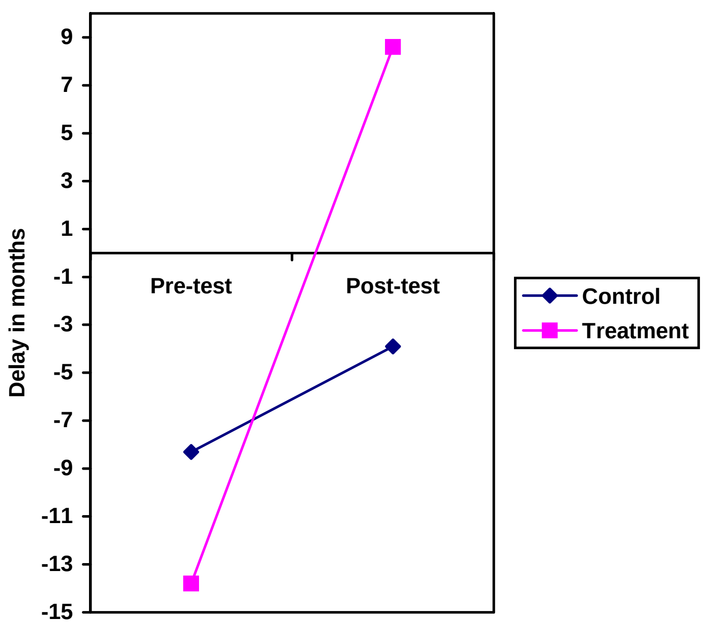


Figure 7: Pseudoword decoding delay

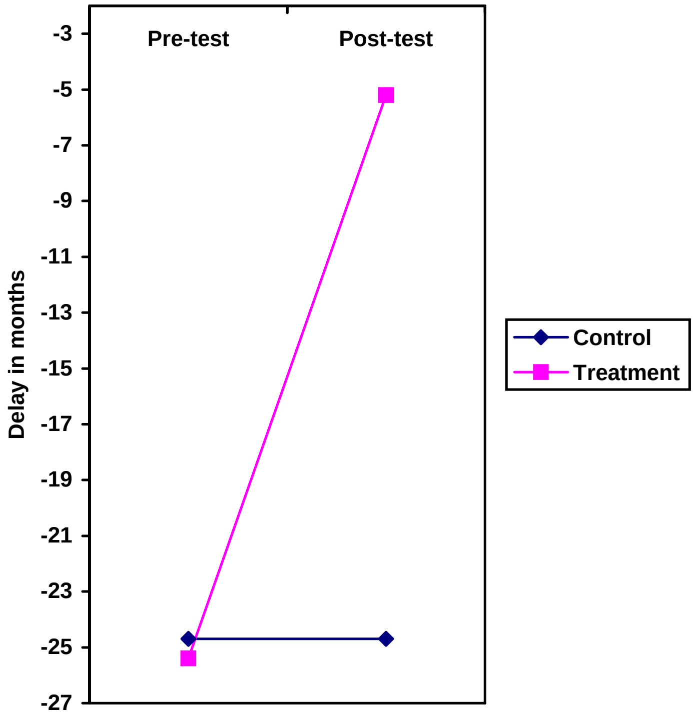
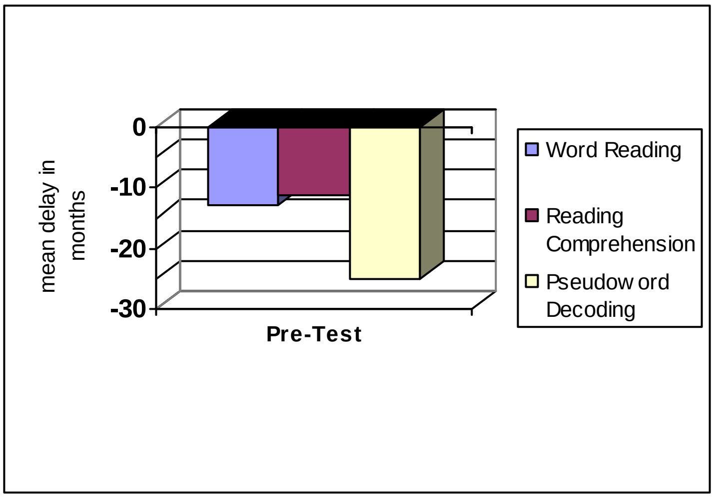


Figure 8: Mean Delay per Sub Test (N=20)



DISCUSSION

Analysis of results data revealed that on every measure of reading ability, performance increased more for the treatment condition than the untreated controls. The magnitude of this effect was evidenced by a difference between post-test means of 3.4 months on the Word Reading task (Figure 5), 18 months on the Reading Comprehension task (Figure 6), and 20.2 months on the Pseudoword Decoding task (Figure 7), all in favour of the treatment condition. However, despite these very large practical gains (particularly for the Reading Comprehension and Pseudoword Decoding tasks), the results failed to produce a statistically significant between-participants effect. It appears that the limited size of the treatment group in this pilot (n = 10), and the large amount of within-group variation which existed in the sample, combined to make detecting a between groups difference unlikely. For example, although an overall between groups difference of 20.2 months existed for post-test means on the Pseudoword Decoding task, the standard deviations were particularly large (pre-control SD = 15.02 months, pre-treatment SD = 13.34 months, post-control SD = 21.84 months, post-treatment SD = 15.47 months). Thus, the combined effect of a small sample size and significant within group variability rendered the power of the design too low to show statistical significance. The trends, however, suggest that replication with a larger sample size would yield highly significant treatment effects.

Consistent with previous research (e.g. Brunswick, McCrory, Price, Frith, & Frith, 1999), the pseudoword decoding task provided a particularly sensitive measure of dyslexia. The average pre-test delay of 25 months on the Pseudoword Decoding task was approximately twice that of either the Reading Comprehension task or the Word Reading task (Figure 8). Thus, although the reading impaired sample presented with generalised reading difficulties at school, these difficulties were disproportionately accounted for by a deficit in phonemic awareness and decoding. This phonological deficit was present for 90% of the sample, irrespective of their age or current grade. Such findings underscore the importance of explicit and systematic instruction in phoneme awareness and phonics as a routine component of a well-rounded reading curriculum (Lyon, 1998), with such training indicated as not only beneficial, but potentially necessary beyond the initial grades (Blachman et al., 2004).

Student compliance with the computer-based treatment was noted to be good, which is consistent with previous studies employing this kind of technology (Mitchell & Fox, 2001). In the current study, students completed an average of 3.6 at-home modules and 1 at-school module each week. Thus, over the 10-week training period, students completed an average of 46 module attempts which represented approximately 11.5 hours of on-computer time. Additionally, an average of 30-minutes per week was spent in direct contact with the researcher who either explained and reinforced concepts introduced by the computer module, or provided the opportunity to further practice emerging phonemic skills with the 'nonsense word game' (described earlier). It appears that this cooperative model of student-driven computer training (11.5 hours) and tutor-driven review and practice (5 hours) provided an effective model of remediation which did not place undue pressure on either the home or the school. This stands in stark contrast to several recent designs which employed specialised tutors to work one-on-one with reading impaired students for up to 50-minutes each day throughout the course of the school year (e.g. Shaywitz et al., 2004).

Strengths of the current program which appeared to maintain student enjoyment and motivation included: consistent and immediate performance feedback via the programs automatic scoring feature, the ability to repeat difficult tasks until mastered, humorous and innovative visual and auditory elements for every task, and the ability to achieve success early in the program without the need for well developed sight-word reading abilities.

Limitations of the current study

Whilst the design of an at-home component to treatment has clear advantages for cost effectiveness and treatment validity, inherent limitations also exist. The greatest potential limitation is that of poor student or parent motivation for the at-home training component. Whilst the current study found a high level of student compliance, this may not always be the case. Thus, it is acknowledged that necessary conditions for success with such a model might include parents who are keen to be involved in the remediation of their own children, and students who are motivated by computer-based learning environments.

Another clear limitation of the current pilot study was the limited size and the high level of variability within the sample. Further research replicating the design with a larger sample would be helpful, as would an extension of the treatment conditions to tease apart the effects of computer-only training versus computer-with-tutor training. Finally, an alternate computer-based activity for the non treated group would help to control for any possible placebo effect due to the novel nature of computer-based treatments.

CONCLUSIONS

The data from this study tentatively support the notion that deficits in phonological processing among dyslexic primary students can be improved by systematic, computer-based training when delivered with cooperation between the home and school, and, supported by tutorial instruction. Furthermore, the data indicate that a larger scale evaluation of reading impaired students using *Phonics Alive! 2: The Sound Blender* (Nelson & Hall, 1999) would produce valuable information about the efficacy and cost-effectiveness of such computer-based training for dyslexic populations.

REFERENCES

Barker, T. A., & Torgesen, J. K. (1995). An evaluation of computer-assisted instruction in phonological awareness with below average readers. *Journal of Educational Computing Research, 13,* 89-103.

Blachman, B. A., Schatschneider, C., Fletcher, J. M., Francis, D. J., Clonan, S. M., Shaywitz, B. A., & Shaywitz, S. E. (2004). Effects of intensive reading remediation for second and third graders and a 1-year follow up. *Journal of Educational Psychology, 96,* 444-461.

Blachman, B. A., Tangel, D. M., Ball, E. W., Black, R., & McGraw, C. K. (1999). Developing phonological awareness and word recognition skills: A two-year intervention with low-income, inner-city children. *Reading and Writing: An Interdisciplinary Journal, 11,* 239-273.

Brunsdon, R. K., Hannan, T, J., Nickels, L., & Coltheart, M. (2002). Successful treatment of sub lexical reading deficits in a child with dyslexia of the mixed type. *Neuropsychological Rehabilitation, 12,* 199-229.

Brunswick, N., McCrory, E., Price, C. J., Frith, C. D., & Frith, U. (1999). Explicit and implicit processing of words and pseudowords by adult developmental dyslexics: A search for Wernicke's Wortschatz. *, 122,* 1901-1917.

Engen, L., & Hoien, T. (2002). Phonological skills and reading comprehension. *Reading and Writing: An Interdisciplinary Journal, 15,* 613-631.

Gillon, G. T. (2002). Follow up study investigating the benefits of phonological awareness intervention for children with spoken language impairment. *International Journal of Language & Communication Disorders, 37,* 381-400.

Gillon, G., & Dodd, B. (1997). Enhancing the phonological processing skills of children with specific reading disability. *European Journal of Disorders of Communication, 32,* 67-90.

Lyon, G. R. (1998). Why reading is not a natural process. Ed*ucational Leadership, 55,* 14-18.

Lyon, G. R., Shaywitz, S. E., & Shaywitz, B. A. (2003). Defining Dyslexia, Co morbidity, Teachers' Knowledge of Language and Reading: A Definition of Dyslexia. *Annals of Dyslexia, 53,* 1-14.

Mitchell, M. J., & Fox, B. J. (2001). The effects of computer software for developing phonological awareness in low-progress readers. *Reading Research and Instruction, 40,* 315-332.

Nelson, K. (Producer), & Hall, J. (Writer). (1999). *Phonics Alive! 2 The Sound Blender* [Computer Software]. Version 1.2. Mona Vale: Advanced Software.

Ramus, F., Rosen, S., Dakin, S. C., Day, B. L., Castellote, J. M., White, S., & Frith, U. (2003). Theories of developmental dyslexia: Insights from a multiple case study of dyslexic adults. *Brain, 126,* 841-865.

Shaywitz, S. E. (2003). Overcoming Dyslexia: A new and complete science-based program for reading problems at any level. Alfred A. Knopf: New York.

Shaywitz, B. A., Shaywitz, S. E., Blachman, B. A., Pugh, K. R., Fulbright, R. K., Skudlarski, P., Mencl, W. E., Constable, R. T., Holahan, J. M., Marchione, K. E., Fletcher, J. M., Lyon, G. R., & Gore, J. C. (2004). Development of left occipitotemporal systems for skilled reading in children after a phonologically-based intervention. *Biological Psychiatry, 55,* 926-933.

Vellutino, F. R., Fletcher, J. M., Snowling, M. J., & Scanlon, D. M. (2004). Specific reading disability (dyslexia): What have we learned in the past four decades? *Journal of Child Psychology and Psychiatry, 45,* 2-40.

Wechsler, D. (1999). *Wechsler abbreviated scale of intelligence.* San Antonio, TX: The Psychological Corporation.

Wechsler, D. (2002). *Wechsler individual achievement test – second edition.* San Antonio, TX: The Psychological Corporation.

Biographical Note:

John Blythe completed the M.Psychol.(Clin.) degree at the UNSW in 2004. He currently works as a clinical child psychologist in western Sydney and as a research psychologist on a study into child psychopathy led by Prof. Mark Dadds through the UNSW and Sydney West Area Health Service.