School of Psychology and Speech Pathology

Cracking the Code: An effectiveness study

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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgement has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Number #HR205/2013.

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Abstract

Numerous studies have reported on the robust relationship between early phonological awareness (PA) and subsequent reading achievement (Gillon, 2005a; National Reading Panel, 2000). Similarly, there is considerable research to support the critical role of the alphabetic principle in predicting and supporting later reading and spelling development (Burgess & Lonigan, 1998; McLachlan & Arrow, 2010). Phonological awareness and alphabet knowledge are highly correlated with the development of reading and spelling (Gillon, 2005; Whitehurst & Lonigan, 1998). Given this association, there has been an increasing push to teach these skills to young children *prior* to word level reading and spelling instruction. This study evaluated the effectiveness of the Cracking the Code (CtC) program with kindergarten students aged 3;8–5;4. CtC is a teacher implemented program, designed to explicitly target PA skills and alphabet knowledge over an 18 week period, within a structured intervention regime (two 55- minute sessions per week).

A pre-test post-test group design was used to evaluate the effectiveness of the program and to identify factors which influence a participant's responsiveness to the program. Four schools in the Perth metropolitan area were randomly assigned to either the control (n=60) or experimental condition (n=60) within a parallel groups design. The control group participated in an alternative program matched for duration (18 weeks) and frequency, targeting the areas of semantics and grammar. All participants were assessed on PA, alphabet knowledge, non-word reading and spelling, oral language, and short term memory prior to intervention and on PA, alphabet knowledge, non-word reading and spelling after intervention.

Results of this study showed that children in the experimental condition improved significantly more in PA, alphabet knowledge, non-word reading and non-word spelling after intervention than the control group. Results also showed that short term memory scores accounted for a significant amount of variance in post-test phonological awareness, non-word reading and non-word spelling outcomes. However oral language measures did not account for a significant proportion of variance in any of the experimental outcome measures. These findings add to the research base regarding the effectiveness of teacher-delivered PA intervention programs; delivered within a classroom setting.

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Introduction

1.1 Background

It was estimated in 2005 that 8% of year three Australian children did not reach the minimum National Benchmarks for Reading (Department of Education, 2005), and in 2013 that the number of year three children who were at or below the minimum standard for reading (the 5th percentile), was 11.4% (ACARA, 2013). Literacy difficulties are widespread in Australia although the prevalence of reading difficulties varies greatly depending on the native language, age, and characteristics of the sample. Struggling readers represent around 10% and up to 15% of the school age population (Torppa, Tolvanen, Poikkeus, Eklund, Lerkkanen, Leskinen & Lyytinen, 2007), with 25% of kindergarten students considered at risk for the development of reading difficulties (Abraham & Gram, 2009). Phonological awareness and alphabet knowledge are highly correlated with the development of reading and spelling (Gillon, 2005a; Whitehurst & Lonigan, 1998). Given this association, there has been an increasing push to teach these skills to young children *prior* to word level reading and spelling instruction, with the aim of facilitating later reading progress. In fact, the development of phonological awareness is addressed in the current Kindergarten Curriculum Guidelines (2015) released by the School Curriculum and Standards Authority. This section of the guidelines requires Kindergarten teachers to introduce syllable and onset-rime awareness, as well as to give attention to the identification of phonemes, specifically the identification of first and last sounds within "simple" words.

A substantial amount of research supports the need for the inclusion of phonological awareness (e.g. Carson, Gillon & Boustead, 2013; Fuchs et al., 2001; McIntosh, Crosbie, Holm & Dodd, 2007) and alphabet knowledge teaching (e.g. Justice, McGinty, Cabell, Kilday, Knighton & Huffman, 2010; Lonigan, Purpura, Wilson, Walker & Clancy-Menchetti, 2013) in the classroom, and highlights the important role of the provision of professional learning and practical support for educators to promote effective teaching strategies and outcomes. Nevertheless, there are limited studies which explore the effectiveness of such classroom based phonological awareness and alphabet knowledge intervention with the younger preschool and kindergarten age groups (e.g. Carson, Gillon & Boustead, 2013; Fuchs et al., 2001; Justice, McGinty, Cabell, Kilday, Knighton & Huffman, 2010; McIntosh, Crosbie, Holm, Dodd & Thomas, 2007).

Most studies have been conducted within small groups under controlled research settings in environments other than the classroom (e.g. Ehri et al., 2001; Gillon, 2000; Gillon, 2005a). Further research conducted within classroom settings is now required to investigate the effectiveness of phonological awareness and alphabet knowledge teaching within the educational setting. The current study, therefore, aimed to add to the research base by evaluating the effectiveness of a school based phonological awareness and alphabet knowledge program implemented by education staff, which incorporates multiple professional learning opportunities and extensive practical support.

1.2 Phonological Awareness

Phonological awareness is the "explicit knowledge of the sound structure of words" (Gillon, 2005b, pp.281) and includes the ability to attend to and make judgments about the sound structure of words (Schuele & Boudreau, 2008). The development of phonological awareness can be placed on a continuum. This continuum moves from larger units, such as the awareness of words in a sentence, to awareness of syllables (e.g. segmentation 'turtle' → 'tur-tle', blending 'ra-di-o' → 'radio'), onset-rime level awareness (e.g. c-at, fl-at), and finally awareness of the smallest unit of sound, the phoneme level or phonemic awareness. Phonemic awareness can be defined as the awareness of each individual phoneme within a word (Ukrainetz, 2009), and the ability to isolate or manipulate these sounds (Schuele &Boudreau, 2008) (e.g. segmentation 'dog' → 'd-o-g', blending 'sh-o-p' → 'shop').

1.2.1 The development of phonological awareness. It has been argued that the development of phonological awareness occurs along a continuum rather than in discrete stages. Anthony, Lonigan, Driscoll, Phillips and Burgess (2003) studied 947 children aged between 2;0 and 6;0 to determine the development of phonological awareness in terms of both linguistic complexity (word, syllable, onset-rime, phoneme) and task complexity (e.g. blending, deletion). The findings of this study support quasi-parallel development of both linguistic and task complexity, indicating that development of phonological awareness is 'overlapping' in nature, where development across both linguistic and task complexity occurs concurrently as opposed to discrete stages. For example children may still be developing later emerging awareness at the syllable level while developing early emerging awareness at onset-rime or phoneme level (Anthony et al., 2003). Early research into

phonological awareness development reported the acquisition of some syllable awareness prior to phonemic awareness, with these larger units described as easiest to detect as they are based around acoustic energy (Liberman, Shankweiler, Fischer & Carter, 1974). Overall, the literature provides general agreement on the order of emergence of these skills but the exact ages at which these skills emerge is more difficult to define, as much of the research into the efficacy and effectiveness of phonological awareness intervention has focused on children aged 5 years and older. More research into the age of development of individual skills is critical in order to provide clear teaching guidelines.

Recent changes to the school starting age and modifications to the national curriculum in Australia (Australian Curriculum Assessment and Reporting Authority, 2012) have resulted in changing expectations for classroom practice. In the Kindergarten Curriculum Guidelines (SCSA, 2015) and the National Curriculum (Australian Curriculum Assessment and Reporting Authority, 2012), there is an expectation for some of these skills to develop between 3;6 – 5;6 years of age, thus placing an expectation on teachers that these skills need to be taught at an earlier age than previously recommended. Expectations of earlier acquisition of reading and spelling, for example in Australia, means that explicit phonemic awareness instruction is now recommended for all children, particularly those identified 'at risk' for reading difficulties (National Reading Panel, 2000). This highlights the need for further investigation into the lower age boundaries at which children are able to acquire these skills. This has also raised the need to evaluate the effectiveness of approaches that have been adapted for younger children to foster these phonological awareness skills.

1.2.2 The significance of phonological awareness - The link to reading and spelling. There is strong evidence to support the relationship between phonological awareness and early reading and spelling acquisition (Gillon, 2005a; National Reading Panel, 2000). At the beginning stages of learning to both read and spell, it is vital that children are able to develop explicit knowledge of the sound structure of spoken language, particularly at the phoneme level (phonemic awareness) (Brann, 1997; Gillon, 2005b), so that they understand the critical concept that letters represent phonemes. Such an understanding is impossible without the insight that words are composed of phonemes.

Phonological awareness (specifically, categorising words by initial, medial or final sound) in 4-5-year-olds is the strongest predictor of reading and spelling in 7-8-year-olds (Bradley &Bryant 1983). Phonological awareness (specifically, deletion tasks at syllable and phoneme level) is also a reliable predictor of word identification and spelling skills over an 11 year period (MacDonald & Cornwall, 1995). Furthermore, Share and Stanovich (1995) report that a large proportion of children who experience reading difficulties present with underlying deficits in phonological awareness skills. Children who experience phonological awareness difficulties in their early years often continue to fall behind their peers (Moore, Evans & Dowson, 2005), with the effects of early reading difficulties being long lasting and closely linked to later reading breakdown (Juel, 1988).

In addition to the extensive evidence that phonological awareness skill predicts later reading success, a substantial amount of evidence supports the explicit teaching of phonological awareness to support the development of reading (e.g. Ehri, Nunes, Willows, Schuster, Yaghoub-Zadeh & Shanahan, 2001). The National Reading Panel (2000) conducted a meta-analysis to examine the effects of phonological awareness instruction on reading and spelling. Overall effect sizes were reported. The effect size of phonological awareness instruction on phonological awareness itself was large, $d = 0.86$, while the effect sizes of phonological awareness instruction on reading and spelling outcomes were moderate, $d = 0.53$ and $d = 0.59$ respectively. The report concluded that specific measures of children's abilities to read both real and non-words showed significant improvement in response to phonological awareness training.

While there is a considerable body of research into phonological awareness intervention, and its effects on reading and spelling development, much of the research has been laboratory based efficacy studies, often conducted with older age groups (5 years and above) (e.g. Ehri, Nunes, Willows, Schuster, Yaghoub-Zadeh & Shanahan, 2001; Nancollis, Lawrie & Dodd, 2005). One of the few studies to investigate a younger age group was that of Lonigan and colleagues (2013) who conducted a study with 324 children (with a mean age of 4;6). Children participated in one of five groups which focussed instruction on different combinations of dialogic reading (a form of interactive shared book reading where the child reads and the adult scaffolds), shared reading (where the adult reads and the child listens), letter knowledge training and phonological awareness training, or the control group

which received the general curriculum. Children in the intervention groups received small group sessions for 10-20 minutes per day, five days per week over the duration of the school year. Results indicated significant effects in treated domains. Those children who received the literacy specific interventions of dialogic reading, phonological awareness and letter sound knowledge experienced significant growth when compared with the control group on reading outcomes, as measured by the Word Identification subtest of the Woodcock Reading Mastery Test-Revised (WRMT-R; Woodcock, 1987).

While this efficacy research provides evidence to support the effect of phonological awareness intervention on reading and spelling under highly controlled conditions, it is critical to investigate whether intervention is successful under 'real world' conditions using effectiveness studies in classroom settings.

1.2.3 Phonological awareness intervention parameters. Research studies which examine the effects of phonological awareness instruction across varying duration, intensity and content have demonstrated different levels of gain in phonological awareness immediately following instruction (e.g. Carson, Gillon & Boustead, 2013; Fuchs, et al., 2001; Kruse, Spence, Olszewski & Goldstein, 2015; McIntosh, Crosbie, Holm, Dodd & Thomas, 2007). Most relevant for the current study are effectiveness studies within classroom settings and those which targeted the earlier age cohort of five years and under. Due to the limited amount of Australian research available in the literature, it is important to consider international research and its application to the Australian context.

When reviewing these studies it is important to consider parameters such as duration, intensity and type of intervention when comparing the delivery and outcomes of phonological awareness programs. Carson, Gillon and Boustead (2013) outline a framework to consider the concepts of program duration and intensity. 'Long' duration programs are defined as those implemented for more than one academic year while 'short' programs are those implemented for less than one academic year. 'Low' intensity programs are those which deliver less than two hours of instruction per week, while 'high' intensity programs involve two or more hours per week. Programs can also be classified with regards to the type of phonological awareness skills being targeted, with programs focussing on a range of phonological awareness levels (e.g. syllable, onset-rime and phoneme) being classified as 'broad' and programs focussed at the phoneme level only, classified as 'narrow'.

One recent small group study has demonstrated success in teaching phonological awareness to 4-year-olds. Kruse, Spence, Olszewski and Goldstein (2015) examined the efficacy of short duration, low intensity, broad phonological awareness and alphabet knowledge intervention for students with phonological awareness deficits. Nine children between 4;0 and 4;11 received small group intervention four to five times per week, 28-36 lessons in total, with each lesson lasting for an average of ten minutes. Phonological awareness intervention focussed on blending and segmenting at the syllable level and the identification of initial sounds in words. Children made gains on phonological awareness progress monitoring measures during the treatment period. Eight out of the nine participants maintained these gains four weeks post treatment. While children made initial as well as sustained gains, it would have been beneficial if follow-up measures were taken beyond a four week period. In addition, the gains reported were based on assessment of the skills explicitly taught within the program (phonological awareness skills), as no measures of reading or spelling were administered. Thus the impact of phonological awareness training on the development of these skills was not investigated.

One study investigated the effects of broad phonological awareness instruction, with a focus on syllable and onset-rime level awareness. McIntosh, Crosbie, Holm, Dodd and Thomas (2007) investigated the effectiveness of a speech pathologist developed, classroom teacher implemented program in the areas of language development (including story retelling, categorisation and following instructions) and phonological awareness. This study was conducted in Australia, and included 97 socially disadvantaged pre-school children aged between 4;5 to 5;1. The phonological awareness activities were linked to books and targeted syllable segmentation, rhyme identification, rhyme generation and initial sound identification. The phonological awareness component of the program lasted for 10 weeks, and included two hours of instructional time per week distributed throughout the day. While this study included information about the phonological awareness tasks involved in the program, little detail was provided regarding the actual implementation of the intervention. Immediately following instruction, significant phonological awareness gains were made by the treatment group when compared with the controls, who were exposed only to their regular curriculum. The results of the study show that a 10 week period of high-intensity instruction focussing on a

broad range of phonological awareness skills generated immediate gains in phonological awareness knowledge. Reading was not measured at the time of the phonological awareness intervention. However, follow up research indicated that the gains in phonological awareness did not result in better reading and spelling scores than the control group, after a two year period. The lack of effect on later reading and spelling may be due to the fact that this program failed to include phonemic awareness as part of its instruction. This finding is particularly important given the extensive research (e.g. Carson, Gillon & Boustead, 2013, Share, Jorm Maclean, Matthews, 1984), which links phonemic awareness, specifically blending and segmenting of phonemes, to more robust reading and spelling outcomes. Phonemic awareness has been found to be the highest predictor of concurrent as well as later reading achievement, over and above measures of memory, vocabulary and socio-economic indexes (Share et al., 1984).

Other research has demonstrated a link between phonological awareness teaching, word decoding instruction and improved reading skill, immediately post-intervention. Fuchs and colleagues (2001) examined the effectiveness of a teacher-delivered phonological awareness program over a 20 week period. Four hundred 4-5 year olds participated in the study. There were three groups in the study, one was provided with phonological awareness and word decoding instruction, one was provided with phonological awareness instruction only, and one was provided with the usual curriculum (control condition). Participants in the two intervention groups received three 15-minute sessions per week focussing on syllable, onset-rime and phoneme level skills, with the inclusion of additional word decoding skills for the phonological awareness plus decoding intervention group. Participants were assessed pre and post intervention using an informal oral segmentation and oral blending task, subtests from the Woodcock Reading Mastery Test (Woodcock, 1998) and the spelling subtest from the Wechsler Individual Achievement Test (Wechsler, 2005). Participants in this short, low intensity, broad program showed significant gains on all assessment measures when compared to the control group, with the phonological awareness plus decoding intervention group showing the largest gains. These results provide evidence to support the inclusion of word decoding and encoding tasks alongside phonological awareness tasks, once children have developed an awareness of individual sounds in words (phonemic awareness). Nevertheless, a follow up study showed that, while participants demonstrated immediate gains, the groups did

not significantly differ five months post intervention. While the parameters of this program yielded immediate gains, the intensity of the instruction may have been insufficient to yield sustained gains, as the total instruction time over 20 weeks was only 15 hours.

While phonological awareness instruction has been shown to be effective in young children, it appears that this success may be related to overall instructional time and to the child's underlying language skills. Justice and colleagues (2010) examined the effectiveness of short, low intensity, broad classroom based phonological awareness instruction with 66 children aged between 3;3 and 5;6. Participants received two, 20-30 minute intervention sessions per week for 30 weeks, focussing on phonological awareness (syllable, onset-rime and initial phonemes within simple words), print vocabulary and narrative. Phonological awareness instruction was provided at least once per week, equalling 10-15 hours of phonological awareness instruction. Children were assessed on language and literacy measures prior to and following the intervention phase. The literacy measures used were; The Rhyming Individual Growth and Development Indicator (Early Childhood Research Institute on Measuring Growth and Development, 2000), and the Alliteration Individual Growth and Development Indicator (Early Childhood Research Institute on Measuring Growth and Development, 2000). The children in the intervention group performed better than the controls on language and literacy measures immediately following the intervention. However, the gains for the children with compromised language abilities were less significant, thus influencing the effects of this intervention for those children with additional language difficulties. It would seem that the overall instructional time (10 -15 hours in total), dispersed over an even longer duration, was not sufficient to produce similar immediate gains for all participants regardless of language ability.

Studies have used a variety of treatment intensities, frequencies and durations. Ukrainetz, Ross and Harm (2009) compared the effects of concentrated (three sessions per week for eight weeks) and dispersed (one session per week for 24 weeks) phonological awareness instruction conducted with 41, 5-6-year-old students, which is a slightly older age group than the other studies reviewed here. Instruction was focussed at the phoneme level, and incorporated both phoneme blending and segmentation skills. These results provide support for the argument that a higher focus on phoneme level awareness results in better outcomes and supports the

inclusion of this instruction to promote reading and spelling development. Furthermore, the results of the study indicate that the immediate gains made from short, intensive concentrated treatment are similar to those from continuous weekly dispersed treatment, indicating no advantage for either approach. Additionally children identified as having mild deficits benefitted more from either intervention regime than did those children who presented with moderate deficits initially.

A recent study demonstrated clear gains in the reading and spelling skills of five-year-olds following phonological awareness training. Carson, Gillon and Boustead (2013) examined the effectiveness of a short, intensive period of phonological awareness instruction, implemented by classroom teachers, in improving reading and spelling achievements. The study included 129, 5-year-olds aged between 5;0-5;2. Thirty-four children received ten weeks of phonological awareness intervention (four, 30-minute sessions per week). The remaining participants continued with their usual reading curriculum which included phonics instruction, but did not explicitly target phonological awareness. The initial focus of the high intensity intervention was rhyme oddity for the first week, followed by a focus on phoneme level tasks for the remaining nine weeks. During the treatment phase, participants were exposed to a range of phonological awareness activities and mastery was not a pre-requisite for moving onto subsequent tasks. There was some inclusion of the letter representations of sounds within 'initial sound' phonological awareness tasks. Results indicate significant and sustained reading and spelling gains over a six-month period when compared with participant controls as measured by the Preschool and Primary Inventory of PA (Dodd, Crosbie, McIntosh, Teitzel & Ozanne, 2000), the Neale Analysis of Reading Ability – 3rd Edition (Neale, 1999), the Burt Word Reading Test (Gilmore, Croft & Reid, 1981), the Schonell Essential Spelling Test (Schonell, 1932) and an informal PA assessment (Carson, Gillon & Boustead, 2011), however no further results have as yet been published on sustained gains beyond this period. The promising results of this study suggest that a high intensity of instruction (two hours per week) and the inclusion of letter representations within selected phonological awareness activities yields sustained gains. However, the participants in this study were aged between 5;0 and 5;2, which is at the oldest age range of the population focus of the current study.

In summary, the findings of this small and emerging body of research reviewed here suggest that intervention lasting for less than 15 hours in total has not been

shown to lead to sustained gains in reading and spelling. Similarly, broad instruction which did not include instruction at the phoneme level was not correlated with sustained reading and spelling gains. The research findings do suggest however that instruction lasting for a short period (18 weeks), which is of low intensity (80 minutes per week, with a total of 24 hours instructional time), with a structured intervention regime, focussing on a range of phonological awareness skills, with particular emphasis on phonemic awareness and inclusion of letter representations within PA activities, can lead to sustained gains in reading and spelling in 3;6 – 5;6 year olds. This highlights the need to undertake research to investigate this further.

1.2.4 Factors influencing the development of phonological awareness. While there is strong evidence to support the fact that large numbers of children aged between 5 and 6 display significant progress following instructional training in the area of phonological awareness (National Reading Panel, 2000), many studies have also found a proportion of children fail to make significant gains (Torgesen, Morgan & Davis, 1992). The body of research considering the links between short term memory and oral language skills, and the development of phonological awareness, suggests that differences in participant profiles may influence their response to intervention.

1.2.4.1 Phonological awareness and oral language. Studies have documented high correlations between young children's general oral language skills and their performance on phonological awareness tasks (Lonigan, Burgess & Anthony, 2000; Storch & Whitehurst, 2002). Cooper, Roth, Speece and Schatschneider (2002) investigated factors which contributed to phonological awareness development. Fifty-two children aged between 5;2 and 6;3 were included in the study. Oral language skills were assessed in Kindergarten using the Peabody Picture Vocabulary Test-Revised (Dunn & Dunn, 1981), the Boston Naming Test (Boston, Goodglass & Kaplan, 1983), the Oral Definitions subtest of the Test of Language Development-P2 (Newcomer & Hammill, 1988), the Test of Auditory Comprehension of Language-Revised (Carrow-Woolfolk, 1985) and the Formulated Sentences Subtest of the Clinical Evaluation of Language Fundamentals-Revised (Semel, Wiig & Secord, 1987). Findings reported that these oral language outcome measures accounted for a significant amount of unique variance in phonological awareness measures (phoneme blending and deletion tasks), increasing with age. The unique amount of variance in phonological awareness accounted for by oral language measures

(collected in kindergarten) was 3% in Kindergarten (5;2-6;3), 5% in first grade and 42% in second grade.

Many studies have also investigated the link between phonological awareness development and specific components of oral language, in particular oral vocabulary. Oral vocabulary measures have been shown to predict phonological awareness skills in children aged between three and four years, specifically those skills associated with larger phonological units such as syllables (Silven, Niemi & Voeten, 2002). Oullette and Haley (2013) investigated the unique variance in phonemic awareness acquisition that could be explained by oral vocabulary and alphabet knowledge. Fifty-seven participants with a mean age of 5;8 were tested initially and then again, one year later. The results of the follow up assessment indicated that oral vocabulary measures accounted for 14% of unique variance in later phonemic awareness (Oulette & Haley, 2013). Wagner, Torgesen, Laughon, Simmons and Rashotte (1993) examined the correlation between phonological processing abilities and general cognitive abilities of 95 students, aged between 5;2 and 7;2. They found significant correlations between measures of expressive vocabulary and measures of phonological awareness. It appears that a significant proportion of the variance related to phonological awareness development can be explained by expressive vocabulary.

Further to this, in the context of the Lexical Restructuring Model (LRM: Metsala & Walley, 1998), Metsala and Garlock (2003) propose that as children learn new words and extend their vocabulary, there is a shift from holistic mental representations of words to a segmented form. This move permits children to access smaller phonological segments of words, which they can then draw on when completing phonological awareness tasks. Thus, the development of a child's lexicon is proposed to have direct links with phonological awareness development. This strong association between vocabulary and phonological awareness supports the theory that the fine phonological discriminations and differentiations required for storage of an increasing number of lexical items, also supports the development of phonological awareness (Evans, Bell, Shaw, Moretti & Page, 2006), indicating that children with a limited vocabulary and by implication, a less segmented lexicon may not be as responsive to phonological awareness intervention.

In sum the results of these studies indicate that children with poor expressive language skills may have more difficulty acquiring phonological awareness skills than children with good expressive language.

1.2.4.2 Phonological awareness and short term memory. It has been suggested that aspects of working memory, specifically short term memory, may be associated with phonological awareness skill (Baddeley, 2003), as phonological awareness tasks involve the temporary storage of words. Working memory involves the temporary storage and manipulation of information. It is presumed to be critical for a broad scope of cognitive activities (Baddeley, 2003). Baddeley and Hitch (1974) proposed a model of working memory which is comprised of a central executive, which functions as the control system and is restricted by attentional resources, and two modality specific systems – the phonological loop and the visuospatial sketchpad. The short term storage and rehearsal of phonological information is theorised to be the responsibility of the phonological loop (Baddeley, 2003). The phonological loop is responsible for holding verbal information over short periods of time; it consists of a phonological store, which retains information in phonological form, and a rehearsal process, which works to preserve deteriorating representations in the phonological store (Baddeley, Gathercole & Papagno, 1998). The phonological loop is proposed to play an important role in processing phonological input and holding this information in short term memory, contributing to an individual's ability to acquire more knowledge of the phonological structure of words, in order for new word learning to take place (Baddeley, 2003; Torgesen & Davis, 1996). Phonological awareness tasks themselves involve the temporary storage of phonological information in order to complete some type of manipulation of sounds (e.g. blending, segmentation, deletion, manipulation), which is facilitated by the phonological loop. These relationships between the phonological loop, word learning and the development of segmented underlying representations of words, suggests that short term memory could impact on a child's phonological awareness capabilities. However, a study carried out by Gillam and van Kleeck (1996) examined the relationship between phonological awareness and phonological working memory, and children's ability to respond to an intervention program designed to develop phonological awareness skills. Results from this study showed that children in the experimental groups (with mean ages of 4;1 and 5;0) with strong phonological working memory (as measured by a non-word repetition task), while

generally presented with stronger overall phonological awareness skills, were no more responsive to phonological awareness instruction than children with poor phonological working memory abilities.

1.3 Alphabet Knowledge

1.3.1 Teaching alphabet knowledge. Due to high correlations seen amongst letter learning (name and/or sound) and reading and spelling development, many theorists emphasise the importance of alphabet knowledge instruction within literacy interventions (Ehri & Roberts, 2006, Foorman, Anthony, Seals & Mouzaki, 2002, Whitehurst & Lonigan, 2002). However, there are also questions raised regarding the need to explicitly teach such knowledge (McGuinness, 2004). While some children may acquire alphabet knowledge from informal or incidental teaching (Aram, 2006), other children, including those at risk for later reading difficulties and those from disadvantaged backgrounds, often do not (National Research Council, 1998). This suggests that gains from incidental teaching may not be adequate for all children, especially those at risk, highlighting the need for explicit teaching. Piasta and Wagner (2010) conducted a meta-analysis of 63 studies investigating the effectiveness of alphabet knowledge instruction, which included a range of participants in the early years of schooling. Studies reported that the rate of improvement of children classified as 'at risk' and those classified as 'typically developing' were equivalent regardless of their initial performance results. Thus, the findings of the meta-analysis suggest that both typically developing children and those considered 'at risk' respond equally as well to current alphabet teaching practices. It may then be hypothesised that more intensive, explicit alphabet instruction may increase the effects of this teaching, as alphabet learning may require considerable amounts of repeated practice (Piasta & Wagner, 2010).

1.3.1.1 Teaching letter names and sounds. The complete scope of alphabet knowledge incorporates the learning of both letter names and letter sounds. While there is evidence to support the teaching of both letter names and letter sounds (Evans, Bell, Shaw, Moretti & Page, 2006; Share, 2004), some researchers argue that the teaching of letter names may not be necessary (McGuinness, 2004; Whitehurst & Lonigan, 1998). After all, knowledge of letter names is not necessary for accurate word reading. Nevertheless, assessments of students with a mean age of 3;8 report significant associations between poor letter name and sound knowledge, and later reading difficulties (Gallagher, Frith & Snowling, 2000). Within Piasta and

Wagner's (2010) meta-analysis, 10 studies provided focussed alphabet instruction. Three of these studies involved the teaching of letter names only, four focussed on letter sounds only, and three studies incorporated instruction in both letter names and letter sounds. Studies where the only alphabet element provided was letter name instruction, showed reliable, positive impacts on children's learning of letter sounds. This suggests that the teaching of letter names transfers to letter sounds, subsequently leading to the improvement of both letter name and sound knowledge. Furthermore, while the teaching of letter sounds yielded a bigger treatment effect on sounds, no transfer to letter name knowledge was reported. These results provide causal support for the argument for letter name-to-sound facilitation, including the principle that letter names provide cues for learning letter sounds (Evans, Bell, Shaw, Moretti & Page, 2006; Share, 2004).

1.3.2 The link to reading and spelling. While phonological awareness is important for later reading and spelling development, it is not sufficient on its own. There is considerable research to support the critical role of understanding the alphabetic principle, i.e. the relationship between sounds and their corresponding letters and letter names, in predicting and supporting reading and spelling development (Burgess & Lonigan, 1998; Gillon, 2005a). There is an increasing amount of evidence that children commencing school with well-developed alphabet knowledge *and* phonological awareness skills are in an advantageous position to learn to read and spell (Whitehurst & Lonigan, 1998). Gallagher, Frith and Snowling (2000) conducted a longitudinal study examining the precursors of literacy delay in 97 children (with a mean age of 3;9). Results from this study reported that letter knowledge measures collected at 3;9 was the strongest predictor of reading and spelling at 6;0.

While the effects of alphabet instruction on alphabet knowledge are generally positive, there remains controversy in the field (Piasta & Wagner, 2010). The results of Piasta and Wagner's (2010) meta-analysis are inconclusive in demonstrating a causative relationship between alphabet knowledge (name and/or sound) and reading and spelling outcomes. However, interventions within many of the studies reviewed by Piasta and Wagner (2010) were not specifically focussed on providing letter name and/or sound instruction, but rather this was included as a minor or incidental section of a larger literacy program, thus making interpretation of the findings somewhat difficult. Piasta and Wagner (2010) offer a number of additional reasons to explain

these results. Firstly, the sub-sample of studies included in the meta-analysis was limited, due to selection criteria for inclusion related to research design and methodology. Furthermore, many were not designed as longitudinal studies linking alphabet knowledge with the development of reading and spelling. Secondly, the content and delivery of instruction across each was variable. Thirdly, a number of these studies also provided some form of literacy instruction to the control group, for example phonological awareness instruction or an alternative form of alphabet knowledge instruction hypothesised to be less effective, which may have influenced the results with regards to reading and spelling outcomes. It is also a possibility that letter name and sound instruction in isolation does not support reading and spelling development unless it is practised within a reading and spelling context. Thus, it could be argued that programs directly focussed on letter name and/or sound instruction, in addition to the use of this knowledge in the context of reading and spelling, would be effective in producing significant results on literacy measures (reading and spelling).

1.4 Multicomponent Programs: combining phonological awareness and alphabet instruction

Once children have well established phonological awareness skills, it is proposed they combine this knowledge with their alphabet knowledge to represent the sounds they can hear using written symbols (Konza, 2006). Within the literature, intervention studies demonstrate more robust treatment effects on reading and spelling outcomes when instruction incorporates *both* alphabet knowledge (name and sound) and phonemic awareness, as compared to phonemic awareness instruction alone. In fact, alphabet knowledge is theorised by many researchers to be a key influence in the emergence of phonemic awareness (Ouellette & Haley, 2013; Ziegler & Goswami, 2005). Burgess and Lonigan (1998) demonstrate a positive reciprocal relationship between the learning of letter-name and sound knowledge and growth in phonological awareness skills in children between 4 and 5 years of age.

The overall findings of this body of research lead to the hypothesis that to maximise effectiveness of pre reading and spelling instruction, both phonological awareness and alphabet knowledge should be given due attention within a multicomponent program, and that this parallel teaching would promote development of both skill sets and subsequent gains in reading and spelling.

1.5 Classroom Instruction

1.5.1 The inclusion of phonological awareness instruction within the classroom. Despite the documented benefit of phonological awareness and alphabet knowledge instruction, not all pre-school classes include teacher directed, explicit instruction of phonological awareness skills as part of their curriculum (Callaghan & Madelaine, 2012). Phillips, Clancy-Menchetti and Lonigan, (2007) report evidence of implicit or explicit teaching of phonological awareness in only 12-15% of the observations conducted in nine pre-school classrooms in the United States. Other studies in the US also document that the average time devoted to the explicit teaching of letter sound relationships is only 3% (National Centre for Early Development and Learning, as cited in Phillips, Clancy-Menchetti & Lonigan, 2008). Kameenui (as cited in Moore et al., 2005) reports that only 5% of students enter their first year of school with some pre-literacy knowledge and then go on to develop the level of proficiency required for reading acquisition with only minimal instruction. Whilst there are no Australian studies of time spent on teacher directed explicit phonological awareness instruction in the classroom, it can be inferred that the patterns from the US studies may apply to the Australian context.

1.5.2 Teacher training. There is strong evidence which links teaching knowledge and teaching practices to children's subsequent reading and spelling outcomes (McLachlan & Arrow, 2010). The National Reading Panel's meta-analysis (2000) indicates that the classroom teacher has a significant effect on the development of children's phonological awareness, reading and spelling skills. The impact of classroom teachers on phonological awareness outcomes resulted in a large effect size (d = 0.78). Similar results were seen for reading and spelling, with effect sizes of d = 0.41 and d = 0.74 respectively. However, it has been found that a significant proportion of teachers lack appropriate knowledge regarding the development and explicit teaching of phonological awareness (Dickinson & Brady, 2005; Menchetti, Lonigan & Farver, 2007; Moats & Foorman, 2003; Zill & Resnick, 2006 in Phillips et al., 2008). Schuele and Boudreau (2008) discuss the valuable role of the speech pathologist within educational teams. They note that speech pathologists have an extensive knowledge base related to the assessment, development and progression of phonological awareness skills, instructional planning and the monitoring of progress which can be transferred to teaching staff. Access to professional learning, intervention protocols, instructional material and

stimuli have a proven effect on the ability of teachers to adequately target these skills (Schuele & Boudreau, 2008). Research indicates that in order to use many of the prevailing language and literacy curricula, numerous teachers need sustained, distributed support (Assel, Landry, Swank & Gunnewig, 2007). El-Choueifati and colleagues (2012) conducted a meta-analysis into which 'early childhood professional skills' had a strong impact on improving the literacy and language outcomes of children. Four main skill categories were identified as being supported by research evidence to improve development; quality adult-child interactions, storytelling skills, supporting peer-to-peer interactions and finally teachers having the skills and knowledge to provide explicit literacy instruction, including phonological awareness, alphabet knowledge and print awareness.

There is some indication that the inclusion of phonological awareness teaching in the classroom can improve with training. Trelani et al. (2015) studied the effects of coaching on increasing teachers' reference to phonological awareness and print within general classroom activities. Following coaching, references made to phonological awareness and print, as measured by rate per minute, were significantly higher for the experimental group. Thus, phonological awareness instructional time can increase following coaching.

1.5.3 Parameters of classroom instruction. The evidence suggests that phonological awareness development is best achieved through one-to-one or a small group instruction (Foorman, Breier & Fletcher, 2003; Lonigan, Schatschneider, & Westberg, 2008). Phillips, Clancy-Menchetti and Lonigan (2008) argue that phonological awareness instruction should be focussed at the appropriate developmental level. Therefore initial assessment results should facilitate 'ability grouping' in order for the explicit instruction of developmentally appropriate skills to take place.

Less is known about intervention parameters associated with phonological awareness instruction when it is conducted in a classroom environment (Carson, Gillon & Boustead, 2013), as most studies have been conducted within small group contexts, within controlled research environments (Ehri et al., 2001; Gillon, 2005a, Gillon, 2000). Therefore, further investigation into the effectiveness of teacher facilitated, classroom based, explicit instruction in the area of phonological awareness is needed. It may also be hypothesised that phonological awareness

intervention focussed at the appropriate developmental level, but targeting a range of skills, would be effective.

1.6 A Classroom Implemented Program

Given the evidence supporting the explicit teaching of phonological awareness and alphabet knowledge skills within early childhood settings, the guidelines from the School Curriculum and Standards Authority which require this teaching, and the reported lack of such instruction in many classrooms, the Cracking the Code program (Fremantle LDC Outreach Service, 2013) was developed. The program was designed and written by speech pathologists and is implemented by trained education staff, who follow carefully scripted lesson plans. The program involves systematic introduction of targets and skills within a small group setting, within the classroom. It is described in detail below.

1.6.1 Cracking the Code. Cracking the Code (Fremantle Language Development Centre (FLDC) Outreach Service, 2013) is a program which has been designed to systematically and intensively target the early developing phonological awareness skills and alphabet knowledge of kindergarten students (3;6–5;6) within the context of classroom based instruction. In Western Australia, kindergarten is the first year of school, although is not compulsory. Children enter their kindergarten year between the ages of 3;6 and 4;6 and attend 2.5 -3 days of school per week. Cracking the Code (CtC) has been developed and trialled within Western Australia, but no studies have yet been conducted to evaluate its effectiveness.

1.6.2 Cracking the Code – Phonological awareness instruction. CtC is a *short duration, low intensity* program which integrates instruction across a *broad* range of phonological awareness skills with an emphasis on phonemic awareness. It uses explicit and developmentally appropriate teaching practices. CtC uses ability grouping, which allows placement of children in the program at a developmentally appropriate point based on their initial assessment results. This is recommended by Phillips, Clancy-Menchetti and Lonigan, (2008) in response to pedagogical research related to 'teaching within the child's zone of proximal learning' (e.g. Bedrova & Leong, 2006) and the evidence supporting small group or individualised instruction (e.g. Rashotte, MacPhee & Torgesen, 2001; Ukrainetz, Ross & Harm, 2009).

CtC was created on the basis that the development of phonological awareness occurs along a continuum but that due to the overlapping nature of phonological awareness development it is not necessary for children to master one level

completely (e.g. onset-rime level) before moving onto the next (Anthony et al., 2003; Phillips, Clancy-Menchetti & Lonigan, 2008, Liberman, Shankweiler, Fischer & Carter, 1974). CtC includes instruction of multiple levels of phonological awareness (see Appendix A for modules) and accommodates the fact that children may still be developing competence in earlier levels while commencing skill acquisition within the more complex levels (Phillips, Clancy-Menchetti & Lonigan, 2008). The program facilitates development of judgement and identification skills prior to blending and segmentation. Whilst the literature emphasises the importance and effectiveness of phoneme level instruction within a narrow program, given the age of the participants and the role of onset-rime and syllable level in developing sensitivity to the sound structure of words, CtC included all levels as a 'broad' program.

The current study thus evaluated the effectiveness of 'broad' phonological awareness instruction (addressing multiple levels of phonological awareness, with an emphasis on phoneme level), targeting the levels of syllable, onset-rime and phoneme level.

1.6.3 Cracking the Code – Alphabet knowledge instruction. In response to the high correlations seen amongst letter learning and reading and spelling development, along with the considerable research to support the critical role of the alphabetic principle in predicting and supporting later reading and spelling development (Burgess & Lonigan, 1998; Gallagher, Frith & Snowling, 2000; Gillon, 2005a), CtC includes alphabet knowledge instruction. Furthermore, CtC incorporates the teaching of both letter names and sounds in response to the literature that links this knowledge to improvements in reading and spelling (Evans, Bell, Shaw, Moretti & Page, 2006; Share, 2004). CtC includes 540 minutes of devoted alphabet instruction time, focussed on both name and sound of all alphabet letters. CtC was created based on the hypothesis that intensive, explicit alphabet instruction would be most effective in promoting learning.

1.6.4 Cracking the Code – Multicomponent instruction. CtC includes both phonological awareness and alphabet knowledge instruction in response to research which identifies both the importance of phonological awareness (e.g. Carson, Gillon & Boustead, 2013; Fuchs et al., 2001; McIntosh, Crosbie, Holm & Dodd, 2007) and alphabet knowledge instruction (e.g., Justice, McGinty, Cabell, Kilday, Knighton & Huffman, 2010; Lonigan, Purpura, Wilson, Walker & Clancy-Menchetti, 2013) in promoting reading and spelling development. However, there is limited research

which examines the effectiveness of programs which incorporate instruction in both (e.g. Gillon, 2005a). Research into the effectiveness of CtC, which incorporates letter name, letter sound and phonological awareness instruction, will add to this limited research base and allow examination of the impact of a multicomponent program on reading and spelling outcomes.

1.6.5 Cracking the Code – Teacher training. There is a large amount of evidence within the literature which supports the importance of teachers' knowledge and teaching practices in effectively supporting children's reading and spelling outcomes (McLachlan & Arrow, 2010). CtC addresses these issues through the inclusion of a professional learning component, which provides training in the theory and practices underpinning the program. CtC also has a modelling and coaching component, provided by a speech pathologist to the teachers.

1.6.6 Cracking the Code – Delivery. Cracking the Code is an 18 week program (designed to be delivered over two school terms) consisting of two 40-minute phonological awareness sessions per week, focussing on a broad range of phonological awareness skills (syllable, onset-rime and phoneme) and two 15-minute alphabet knowledge sessions per week.

1.7 Summary and Research Questions

The purpose of the current study was to examine the effectiveness of the Cracking the Code program in improving the phonological awareness skills and alphabet knowledge (name and sound) of kindergarten students. In addition, this study aimed to examine the effectiveness of Cracking the Code in improving emerging reading and spelling abilities in participating children, and finally identifying factors which may impact participants' responsiveness to the intervention.

Hypotheses:

1. Cracking the Code (CtC) will improve the phonological awareness skills of kindergarten students (kindergarten age range: 3;6-5;6).
2. The Cracking the Code program will improve the alphabet knowledge skills of kindergarten students (kindergarten age range: 3;6-5;6).

3a. The Cracking the Code program will improve the non-word reading skills of kindergarten students (kindergarten age range: 3;6-5;6).

3b. The Cracking the Code program will improve the non-word spelling skills of kindergarten students (kindergarten age range: 3;6-5;6).

4. The effectiveness of the Cracking the Code program will be influenced by participants' oral language and short term memory capabilities. Specifically, children with stronger oral language and short term memory skills will show greater responsiveness to the Cracking the Code program.

2. Method

2.1 Participants

A total of 120 kindergarten students (68 girls and 52 boys) with a mean age of 4;2 years (SD=3.36 months) participated in the study. Participants were drawn from four mainstream schools within the South West Perth Metropolitan area. Schools within this area are serviced by a team of speech pathologists (Support Officers, Speech and Language), employed by the Department of Education to provide consultative support to education staff in the areas of speech, language and literacy development. Schools involved in the study were matched based on the following characteristics: (1) geographical location and (2) socioeconomic status. Following ethics approval, principals of all 40 Department of Education primary schools within the South West Perth Metropolitan area (not currently implementing Cracking the Code or Words Grammar and Fun) were invited to participate in the study. Ten schools confirmed interest in their kindergarten students taking part in the study. From these schools, four were considered unsuitable due to insufficient student numbers, differing school structures, current access to external speech pathology services or previous access to professional learning and programing support from an education department speech pathologist familiar with the CtC program. From the remaining six schools, four were selected for participation on the basis of similar Socio Economic Status scores (IRSAD - The index of relative Socio-economic Advantage and Disadvantage). IRSAD scores summarise the economic and social conditions of people and households within a geographical area. Schools selected received decile scores of nine and ten, indicating that selected schools were classified as having a lack of disadvantage and greater advantage in general. The researcher met with the principal of each selected school to discuss the research project and outline the participation requirements. Roles and responsibilities for implementing the program were defined. The principal was provided with a written outline of the research project information, and a consent form to indicate the school's participation in the study. Schools were then randomly assigned to either the experimental or control condition. Each school was allocated a number from 1-4

based on alphabetic order, and a random number sequencer was then used. The first two schools were allocated to the experimental condition, and the remaining two schools were allocated to the control condition.

Information regarding the project and a consent form were sent home via each participating school to all kindergarten students. Parents/guardians signed consent forms and returned them to the classroom teacher to indicate their consent, as well as their child's consent to take part in the study. As the oral language programs were implemented across the whole class, all kindergarten children took part in the oral language programs as part of their regular classroom activities; however only those children who had parental/guardian consent were eligible to have their data included in the research project. Consent forms were returned for 171 students, however due to time and financial constraints, 120 students overall (which exceeded the amount required for statistical power), comprising 30 from each school were randomly selected for inclusion in the study. Consenting students from each school were allocated a number based on alphabetic order (by class, and then by surname). A random number sequencer was then used, and the first 30 numbers were used to select students from each school. The participant flow in Appendix B outlines the progression of participants over the duration of the study.

2.2 Materials

2.2.1 Background assessment measures. Children were tested prior to the intervention program in order to determine overall oral language and short term memory capabilities. Details of each test are outlined below.

2.2.1.1 Clinical Evaluation of Language Fundamentals – P2 (Wiig, Secord & Semel, 2006). The Core Language Subtests from the CELF-P2 (Wiig, Secord & Semel, 2006) were individually administered to all participating children in order to provide a measure of overall language ability. Results can be found in Table 1. The Core Language Subtests of the CELF-P2 include sentence structure, word structure and expressive vocabulary. The CELF P-2 (Wiig, Secord & Semel, 2006) has high test-retest reliability, with correlation coefficients of 0.91 – 0.94 for composite language scores, and high validity, with scores from inter correlational studies ranging from 0.84 – 0.94.

2.2.1.2 Early Repetition Battery (Seeff-Gabriel, Chiat & Roy, 2008). The Preschool Repetition Subtest from the Early Repetition Battery (Seeff-Gabriel, Chiat & Roy, 2008) was administered to all participants to measure short term memory

capabilities. Results can be found in Table 1. The Preschool Repetition Subtest has alpha levels of 0.89, 0.81 and 0.97 for internal consistency, test-retest reliability and interrater reliability respectively.

Table 1

Participant Description

Variable	Condition	Mean	95% Confidence Interval (Lower)	95% Confidence Interval (Upper)	Standard Deviation	Minimum	Maximum
CELF –P2	Control	101.27	97.37	105.17	14.95	45	132
	Experimental	98.90	94.80	103.00	15.87	53	126
ERB	Control	106.37	101.20	111.54	19.83	1	130
	Experimental	108.00	103.22	112.78	18.52	54	130

Note. CELF P2 = Clinical Evaluation of Language Fundamentals; ERB = Early Repetition Battery

2.2.2 Experimental measures. The following measures were used to measure pre- and post- intervention performance for each dependent variable.

2.2.2.1 Cracking the Code Phonological Awareness Assessment (FLDC Outreach Service, 2013). The Cracking the Code Phonological Awareness Assessment (CTCPAA) was administered in order to assess the specific skills targeted within the program by using items which were not directly taught. The CTCPAA was designed for use with students from kindergarten to year one, and was developed for use with the CtC program. The assessment is comprised of two syllable level subtests, six onset-rime level subtests and 11 phoneme level subtests, details of which can be found in Table 2 below. A copy of the assessment can be found in Appendix C.

Table 2

Cracking the Code PA Assessment Overview

PA Level	Subtest	Number of Items	Example Task Instruction
Syllable	Blending syllables	10	What is the word I am saying *win-dow*?
	Segmenting syllables	10	Can you show me (by tapping out or clapping) the syllables in *letter*.
Onset-Rime	Rhyme detection	10	What rhymes with *dog: red or log*?
	Rhyme generation	10	Think of some words that rhyme with *fish*.
	Blending onset and rime (CVC)	10	What is the word I am saying *s-un*?
	Naming onset (CVC words)	10	What is the first sound you can hear in *seat*?
	Onset deletion (CVC)	10	Say *dig* without the *d*.
	Onset manipulation (CVC)	10	Say *pen* but change the *p* to a *t*.
Phoneme	Naming final sound (CVC)	10	What is the last sound you can hear in *late*?
	Phoneme blending (CVC)	10	What is the word I am saying *p-a-n*?
	Phoneme blending (CCVC)	10	What is the word I am saying *f-l-a-g*?

	Phoneme blending (CVCC)	10	What is the word I am saying *p-a-s-t*?
	Segmenting CVC words	10	Tell me all the sounds you can hear in *feet*.
	Naming medial sound (CVC)	10	What sound is in the middle of *pet*?
	Segmenting CCVC words	10	Tell me all the sounds you can hear in *clap*.
	Segmenting CVCC words	10	Tell me all the sounds you can hear in *cost*.
	Deleting initial sound CCVC	10	What is *plane* without the *p*?
	Manipulating initial sound CCVC	10	Say *plate* but change the *p* to a *k*.
	Manipulating medial sound CVC words	10	Say *dog* but change the *o* to an *e*.

2.2.2.2 Alphabet knowledge assessment. This assessment required participants to provide the name and sound of each of the 26 letters of the alphabet, from both upper case and lower case forms. Children were shown written representations of each letter individually, and asked to identify the name of the letter, and the sound the letter makes. Letters were presented in the same order to all children, and all lower case letters were presented, followed by all upper case letters.

2.2.2.3 Non-word reading and spelling assessment (FLDC Outreach Service, 2014). The assessment is comprised of 10, three letter non-words. Items include a range of short vowels and consonants. The assessment consists of two subtests: non-word spelling and non-word reading. Within the first subtest, children were asked to spell each of the ten non-words from dictation. In the second subtest children were asked to read each of the ten non-words from a standardised stimulus sheet. Words were presented in lowercase New South Wales Foundation font. Within each of the two subtests the non-words were presented consistently to each child in a random

order, this order differed between subtests. A copy of the assessment can be found in Appendix D.

2.2.3 Fidelity Measures.

2.2.3.1 Teacher questionnaire. Teacher questionnaires were completed by participating staff following the intervention phase of the study. The questionnaire was comprised of questions relating to adherence to intensive oral language program protocols as well as questions related to staff consistency and training. Questions about teaching practices and instructional time in the areas of phonological awareness and alphabet knowledge outside of the intervention program, were also included. A copy of the questionnaires can be found in Appendix E.

2.3 Intervention

The Cracking the Code Program (CtC; FLDC Outreach Service, 2014), which is a speech pathologist developed program designed to systematically and intensively target the early developing phonological awareness skills and alphabet knowledge of kindergarten students (3;6–5;6), was used with the experimental group during the intervention phase of this project. CtC has 10 sequential modules which increase in complexity (see Appendix A). Each of the ten modules contains four phonological awareness activities, and each module targets a range of phonological awareness levels (i.e. syllable, onset-rime, phoneme). Each phonological awareness activity includes all resources required for implementation of the activity (e.g. picture cards, manipulatives), as well as a detailed task instruction card outlining the goal of the activity, a script for introducing the task to the students, as well as increased and decreased steps for making the goal and the task easier or more difficult. A sample activity can be found in Appendix F.

The Words, Grammar and Fun program (WGF; FLDC Outreach Service, 2014) was used with the control group during the intervention phase of this project. WGF has six sequential blocks which increase in complexity (see Appendix G). Each block contains one grammar and one semantics activity. Each activity contains all resources required for implementation (e.g. picture cards and game pieces), as well as a detailed task instruction card outlining the goal, task explanation script and ways to simplify or extend the task depending on the child's performance. A sample activity can be found in Appendix H.

2.4 Experimental Design

Schools were randomly assigned to either the experimental or control condition within a parallel group design. Schools in the experimental group participated in the CtC program, and control groups participated in the WGF program. The programs were matched for intensity and duration of the intervention period. A pre-test/post-test analytical design was used to determine the effectiveness of CtC in improving the phonological awareness skills and alphabet knowledge of kindergarten students, as well as their reading and spelling development.

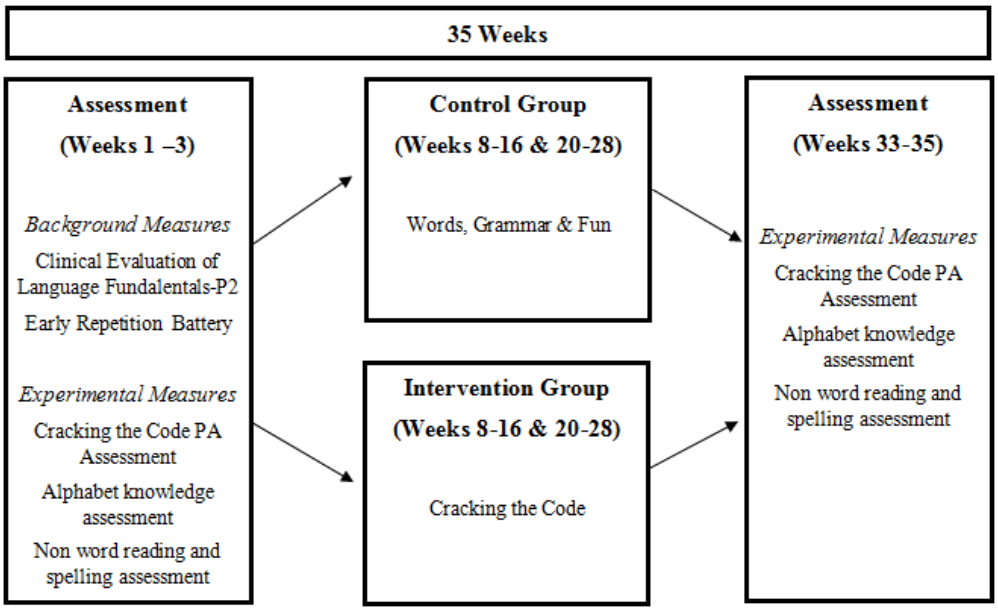

Figure 1

Experimental Design Summary

2.5 Procedure

2.5.1 Informed consent. Prior to the onset of the study, approval was obtained from Curtin University's Human Research Ethics Committee and the Department of Education, WA. Participating schools, as well as parents or guardians of each student provided written informed consent on an approved consent form. Additionally, each student also provided written informed consent by circling 'yes' on a consent form, once their participation in the project was explained to them by their parent/guardian. Following this, prior to the administration of the assessments, children were provided with a brief simple explanation of the assessment requirements, and invited again to circle 'yes' on an additional consent form if they gave their consent to continue with assessment administration, as per Department of Education WA guidelines.

2.5.2 Assessment. Each student was tested prior to the intervention phase (see Figure 1) and after the conclusion of the intervention (see Figure 1). Speech pathologists from the Department of Education W.A. administered all standardised background measure assessments (CELF-P2, ERB), prior to the intervention phase, under the supervision of the primary researcher. These speech pathologists were not blind to the experimental/control groups.

All experimental assessments were administered both pre- and post-intervention by trained research assistants (speech pathologists) who were blind to research group allocation. The research assistants were trained by the primary researcher, and were observed administering the tests to confirm adherence to test procedures before they tested independently.

After the intervention phase, teachers were asked to complete a questionnaire (see Appendix E). These questionnaires were distributed to each teacher and returned directly to the researcher once completed. Questionnaire data was identifiable by the researcher, however all responses remained confidential and were not shared with other school staff.

2.5.3 Intervention procedures.

2.5.3.1 Teacher training. During term one, all school staff from participating schools involved in the experimental condition (CtC), including school administration staff, teachers and education assistants, underwent professional learning in accordance with the Cracking the Code protocol. This three hour training session outlined the development of alphabet knowledge, phonological awareness and phonics knowledge. Education staff directly involved with the implementation of the program received additional training in assessment requirements, program logistics and intervention strategies. During the intervention stage, modelling and coaching visits were conducted at three weekly intervals by the primary researcher. During these visits the primary researcher met with the classroom teacher to discuss the progression of the program and work through any issues that may have arisen. These visits also involved a modelling component, where the primary researcher demonstrated the implementation of four phonological awareness activities (40 minutes).

Similar training and support was provided for schools in the control condition (WGF) in accordance with the Words, Grammar and Fun protocol. All staff participated in a three hour training session covering theory outlining the

development of semantics and grammar, with staff directly involved with the implementation received additional training in assessment and program logistics. The same structured modelling and coaching visits were also provided at three weekly intervals, as was outlined for CtC, however, only two activities were modelled each time (20 minutes), as the WGF program only has two activities per block.

2.5.3.2 Program implementation – Experimental group. Based on the phonological awareness and alphabet knowledge initial assessment data, participants from each class (along with all remaining children whose data was not included in the study) were 'like' ability grouped into three groups (consisting of four to seven children) and placed into a 'starting module' for phonological awareness. Allocation of starting modules for each group followed a two-step process. Groups were first allocated to starting modules on the basis of phonological awareness assessment scores, and an experienced speech pathologist reviewed the scores and original assessment data to ensure that the scores were reflective of the participants' skill level.

During the intervention phase, in terms two and three, all kindergarten students within schools allocated to the experimental condition, participated in 40 minutes of small group phonological awareness instruction twice per week, across 18 weeks as part of the CtC program (24 hours of intervention time in total). Within each biweekly session, three trained education staff members were responsible for delivering the four phonological awareness activities (within the relevant module), to their designated student group. Each activity lasted for 10 minutes, totalling 40 minutes of phonological awareness intervention for each session (a total of 80 minutes per week). Each phonological awareness module was completed over three weeks, with student groups repeating the same four activities included within the module twice per week, totalling six repetitions of each activity, with varied items/targets, during the three week period. Groups then progressed to the next module of activities and the process was repeated over the next three week period. Participants completed six modules in total over the duration of the intervention phase, 18 weeks in total. The exact modules completed by each group of students were dependent on their assigned starting module. Within the two experimental group schools, seven kindergarten classes implemented the CTC program. There were 20 small groups of students within these classes. Of these small groups, seven completed modules 1-6, ten completed modules 2-7, and three completed modules 3-

8. Over the duration of the intervention phase, all small groups, regardless of their starting module, completed syllable, onset-rime and phoneme level activities.

The alphabet knowledge component of the CtC program was also implemented twice per week for the duration of the intervention phase, at a separate time to the phonological awareness component. Each of the 36 sessions ran for 15 minutes (nine hours of intervention time in total), with some activities being implemented at a whole class level, and some at a small group level. The activities followed a six session cycle across the 36 sessions and each cycle focused on a specified range of letters (e.g. s,a,t,p,i,n). The first session within the cycle focused on an explicit introduction to the letter names and sounds using grapheme flash cards. The second session focused on identification of graphemes from a 'letter board' when provided with a name or sound. The third session of the cycle focused on the naming of the letter names and sounds, as well as the matching of upper case to lower case graphemes. Sessions four and five targeted written formation of both lower case and upper case graphemes respectively, and the final session in the cycle was a revision activity where children were required to expressively identify letter names and sounds from grapheme flash cards. An example alphabet knowledge activity can be found in Appendix I.

2.5.3.3 Program implementation – Control group. Following collection of initial assessment data, participants from each class were placed into one of three 'mixed ability groups' (in contrast to the like-ability groups used in CtC). All groups commenced with the first block of activities within the Words, Grammar and Fun (WGF) program, and all children completed the same activities in the same order in accordance with the Words. Grammar and Fun intervention protocol.

During the intervention phase, in terms two and three, in accordance with the Words, Grammar program, all kindergarten students participated in 20 minutes of small group semantics and grammar instruction twice per week across 18 weeks (12 hours of intervention time in total). Within each biweekly session, two trained education staff members were responsible for delivering one semantic and one grammar activity to each of the three student groups within the classroom. Each activity lasted for 10 minutes, totalling 20 minutes of direct intervention for each session. As they rotated through the activities, the group not participating in either the semantics or grammar activity at any given time, took part in an independent activity of the teachers choosing. These independent activities were play based and

unrelated to the program. Each block lasted for three weeks, with groups completing both activities within the block twice per week over the three week period, so six repetitions of each activity in total. Groups then progressed to the next block of activities, and the process was repeated over the next three week period. Students completed all six blocks of activities over the duration of the intervention phase, 18 weeks in total. Within the two control group schools, five classes implemented the WGF program, with 15 small groups across these classes in total. All groups completed the same blocks (1-6) over the duration of the intervention phase.

2.5.3.4 Treatment fidelity. To facilitate treatment fidelity, clear guidelines for dosage and implementation, as well as comprehensive training and modelling support, were provided. The CtC and WGF instruction cards were used in training and supported adherence to the intervention protocol. In order to measure treatment fidelity, teacher questionnaires, records of activity implementation and modelling lessons every three weeks, by the primary researcher were also used. During these modelling sessions, each education staff member involved in program implementation was given the opportunity to observe the primary researcher (speech pathologist) conducting 1 – 2 , 10-minute grammar and semantics activities with a small group of children.

3. Results

Multilevel modelling was used to determine the effectiveness of Cracking the Code in improving phonological awareness, alphabet knowledge, non-word reading and non-word spelling in kindergarten students. Analyses of participant outcomes were conducted using multilevel modelling as participants were nested within schools. The influence of socio-economic status on the participants' enrolled schools, represented by the IRSAD measure, was treated as a random factor. Analyses of participant outcomes were conducted using a combination of raw and standardised scores. Standard scores were used where available, i.e., for short term memory as measured by the Early Repetition Battery (Seef-Gabriel, Chiat & Roy, 2008) and for oral language as measured by the Core Language Score from the CELF-P2 (Wiig, Secord & Semel, 2006). Raw scores were used for the remaining experimental tasks as standard scores were not available (i.e., phonological awareness, alphabet knowledge, non-word reading and non-word spelling). Across the data set, 7.50% of data was missing due to participant absence on the assessment date or students exiting the school. Missing data was dealt with by multiple imputation methods.

Multilevel modelling allows for imputation of missing data, while considering the non-random nature of the data, to enable efficient analysis (Field, 2013).

Descriptive scores can be seen in tables 3, 4, 5 and 6. Scores for phonological awareness, alphabet knowledge, non-word reading and non-word spelling all increased over the treatment period for both groups. Ten percent of the measures were re-scored to assess reliability. One hundred percent agreement was achieved for re-scoring of the CELF-P2, CtC PA Assessment, Alphabet Knowledge Assessment, Non Word Reading Assessment and Non Word Spelling Assessment; Ninety-two percent agreement was achieved when re-scoring the ERB. The experimental group showed greater gains than the control group, on average, from pre-test to post-test. Multilevel modelling followed by moderation analysis was used to determine if the experimental group improved significantly more than the control group, with relevant factors controlled. Each of the hypotheses will be addressed in turn.

Table 3

Descriptive Statistics

Variable	Condition	Mean Score Pre Intervention (SD)	Mean Score Post Intervention (SD)
Phonological Awareness	Control	23.15 (16.17)	51.11 (28.76)
	Experimental	25.53 (25.53)	80.02 (35.79)
Alphabet Knowledge	Control	14.09 (18.45)	32.7 (24.68)
	Experimental	22.16 (22.78)	64.84 (30.75)
Non-Word Reading	Control	1.34 (3.73)	6.83 (7.62)
	Experimental	3.22 (7.14)	19.08 (11.89)
Non-Word Spelling	Control	0.77 (2.60)	6.13 (9.19)
	Experimental	1.55 (5.09)	11.82 (12.39)

Table 4

Phonological Awareness Level Descriptive Statistics

Condition	Variables					
	Pre Syllable Mean (SD)	Post Syllable Mean (SD)	Pre Onset-Rime Mean (SD)	Post Onset-Rime Mean (SD)	Pre Phoneme Mean (SD)	Post Phoneme Mean (SD)
Experimental	10.59 (4.29)	16.43 (2.70)	10.31 (10.00)	34.10 (13.84)	3.84 (14.51)	29.49 (22.49)
Control	12.05 (3.68)	15.45 (2.94)	8.59 (7.53)	24.74 (13.73)	2.18 (7.69)	10.92 (15.05)

Table 5

School Level Phonological Awareness Descriptive Statistics

Variable	School			
	Experimental School 1	Experimental School 2	Control School 1	Control School 2
Phonological Awareness – Pre Mean (SD)	16.11 (6.41)	33.33 (30.81)	23.93 (20.10)	21.63 (8.66)
Phonological Awareness – Post Mean (SD)	62.48 (26.17)	96.88 (35.01)	57.59 (30.56)	44.38 (24.40)

Table 6

Alphabet Knowledge Descriptive Statistics

Condition	Variables			
	Pre Letter Name Mean (SD)	Post Letter Name Mean (SD)	Pre Letter Sound Mean (SD)	Post Letter Sound Mean (SD)
Experimental	14.69 (14.08)	33.14 (16.28)	9.78 (10.44)	31.71 (15.52)
Control	9.34 (11.61)	17.71 (13.29)	4.40 (8.04)	14.57 (12.44)

3.1 Baseline Equivalence

A series of independent t-tests were carried out in order to confirm that the groups did not differ in age, oral language and short term memory skills prior to intervention. None of the statistical assumptions were violated prior to analysis. The groups did not differ significantly on age $t(117) = 0.91$, $p = .362$, two tailed, $d = .17$, oral language, $t(117) = .84$, $p = .404$, two tailed, $d = .15$ or short term memory, $t(117) = -.46$, $p = .644$ two tailed, $d = .09$.

3.2 Intervention and Phonological Awareness

3.2.1 Multilevel modelling. Prior to interpreting the results of the hierarchical model, several assumptions were evaluated. First, stem-and-leaf plots and boxplots were examined and univariate outliers were removed. Subsequent examination showed that each variable was normally distributed, and did not contain further univariate outliers. Second, review of the scatterplot of standardised residuals against standardised predicted values indicated that the assumptions of normality, linearity and homoscedasticity of residuals were met. Third, multivariate outliers were not of concern as Mahalanobis distances did not exceed the critical value for any cases in the data file. Finally, tolerances for all predictors in the final model indicated that multicollinearity was not problematic.

In order to determine which factors contributed to post treatment performance in PA, in the manner outlined in Field (2013), a hierarchical model was constructed to explain the variance in post–test PA scores accounted for by the predictors within

the model. The random effect of SES was included as a level two variable, in order to control for the differences SES had on the remaining level one predictor variables within the multilevel model. The level one fixed predictor variables (participation in CtC, pre PA scores, short term memory scores and oral language scores) were then added to subsequent models in the described order, each model differing by only one parameter. This allowed for comparisons between models to ascertain the amount of variance each predictor added to each model, while controlling for other predictor variables within the model. Due to the nature of multiple model-wise comparisons and the risk of inflated family-wise error rate that would rise as a result, model fit change was evaluated against a more conservative critical chi square value of $\alpha = .01$ (Field, 2013).

Within the null (no predictor) model, SES was shown to significantly predict post-intervention phonological awareness scores, F (1, 2) = 90.34, $p = .011$. The intra-class correlation coefficient (ICC) was used to calculate the proportion of the total variability in the outcome that was attributed to SES differences. Calculations showed 6.88% of variance was accounted for by SES. This finding reinforced the value of a multilevel analysis approach, as the higher level predictor accounted for over 5% of the variance in the outcome variable (Heck, Thomas, & Tabata, 2014).

Within the second model, participation in CtC was entered as a fixed predictor, while controlling for the effects of SES. Participation in CtC significantly predicted post-intervention phonological awareness scores F (1, 97) = 21.81, $p < .001$. Comparisons between the -2 log-likelihood (*-2LL*) coefficient of this model and the previous null model, and conversion of this value to reflect model chi-square change, was used to estimate whether significant additional variance in post-PA scores was accounted for by participation in CtC. A difference between the null model (*-2LL* = 962.76) and the model adding participation in CtC as a predictor (*-2LL* = 943.10) was significant, χ^2 (1) = 19.66, $p < .01$. A change in R^2 of .18 indicated that participation in CtC explained approximately 18% of the variance in post-intervention PA scores. Participation in CtC therefore accounted for significant variance in post-intervention PA scores after accounting for the influence of SES.

In order to control for the effect of pre-test PA on post-test PA scores, pre-test PA was added as a fixed predictor to the model. Pre-test PA accounted for a significant proportion of variance in post-test PA, F (1,98.80) = 121.11, $p < .001$, -2LL = 864.97 (Δ-2LL = 78.13), $\Delta R^2 = .54$. Participation in CtC remained a

significant predictor of post-test PA after the contribution of pre-test PA was accounted for F (1, 96.89) = 53.42, $p < .001$.

Short term memory scores were added as a fixed predictor to control for short term memory differences in the estimation of CtC's influence on post-test scores. Word/non-word repetition scores accounted for a significant proportion of variance in post-test PA scores, F (1, 96.97) = 22.40, $p < .001$, -2LL = 844.78 (Δ-2LL = 20.19), $\Delta R^2 = 0.19$. Participation in CtC remained a significant predictor after word/non-word repetition scores were accounted for, F (1, 96.89) = 64.82, $p < .001$.

To control for language differences in the estimation of CtC's influence on post-test scores, oral language scores were entered as a fixed predictor in the final model. Oral language scores did not account for a significant proportion of variance in post-test PA scores, F (1, 97.40) = 5.54, $p = .021$, -2LL = 839.41 (Δ-2LL = 5.37), $\Delta R^2 = .05$. Participation in CtC remained a significant predictor after oral language scores were accounted for, F (1, 96.88) = 71.51, $p < .001$. The change from the baseline model to the final model (as shown in Table 7) is significant, indicating that the final model, inclusive of all parameters explains a significant amount of variance in post-intervention PA scores.

In summary, participation in CtC resulted in significant improvement in PA scores after controlling for potentially confounding variables (SES, pre-test PA, short term memory and oral language). This finding therefore supports Hypothesis 1, that the Cracking the Code intervention program was effective in increasing the phonological awareness of participants.

Table 7

Post Phonological Awareness Scores - Final Multilevel Model

Parameter	Model 1	Model 2	Model 3	Model 4	Model 5
Level 2					
SES	90.34 (0.11)	47.74* (0.008)	3.76 (0.073)	12.75* (0.001)	19.02* (<0.001)
Level 1					
Participation in CtC		21.81* (<0.001)	53.42* (<0.001)	64.82* (<0.001)	71.51* (<0.001)
Pre Total Phonological Awareness Score			121.11* (<0.001)	94.64* (<0.001)	92.06* (<0.001)
Short Term Memory				22.40* (<0.001)	14.44* (<0.001)
Oral Language					5.54 (0.021

Note: SES = Index of Relative Socio-Economic Advantage and Disadvantage, Short Term Memory = ERB Pre-School Repetition Subtest, Oral Language = CELF P2 Core Language Score

3.2.2 Follow up moderation analyses. Previous analyses showed that participation in CtC explained a significant amount of variance in phonological awareness (PA) post-test scores. Based on these results, the strength and direction of the relationship between participation in CtC and post-test PA scores was examined. Of particular interest, was whether this relationship between participation in CtC and post-test PA scores, was conditional on pre-test PA scores, when short term memory, oral language and SES were controlled for. A moderation analysis showed the effects of participation in CtC on post-test PA scores were not conditional on participants' pre-intervention PA scores, F (1, 92) = 2.29, p = .134, ΔR^2 = .01. A subsequent moderation analysis was conducted to examine whether the influence of participation in CtC on post-intervention PA was conditional on the participants' short term memory after controlling for SES, oral language and pre-intervention PA scores. Short term memory similarly did not provide a conditional influence on the relationship between participation in CtC and post-intervention PA scores, F (1, 92)

= 0.54, p = .463, ΔR^2 = .002. Therefore the improvements seen in PA skills as a result of participation in the Cracking the Code program, were not conditional on pre-test PA scores or short term memory. These results indicate that regardless of onset scores, children responded equally as well to the program.

3.3 Intervention and Alphabet Knowledge

3.3.1 Multilevel modelling. Prior to analysis, six extreme univariate outliers were removed, and the pre alphabet knowledge score variable was algebraically transformed to improve univariate normality. All remaining assumptions as outlined in the prior analysis were met prior to the forthcoming analysis**.**

A hierarchical model was constructed to explain the variance in post alphabet knowledge scores accounted for by the predictors within the model. The random effect of SES was again included as a level two variable. Level one fixed predictor variables (participation in CtC, pre alphabet knowledge scores, short term memory scores and oral language scores) were then added to successive models in the aforementioned order. Again model fit change was evaluated against a critical chi square value of of α = .01 (Field, 2013).

Within the null model, SES was shown to significantly predict post alphabet knowledge scores, F (1, 2) = 97.33, p = .010. The intra-class correlation coefficient (ICC) was used to determine the proportion of the total variability in the outcome that was attributed to SES differences. Calculations showed 2.96% of variance was accounted for by these differences.

Within the second model, participation in CtC was entered as a fixed predictor, while controlling for the effects of SES. Participation in CtC was significant in predicting post-intervention alphabet knowledge scores F (1, 96) = 31.07, p < .001. The -2 log-likelihood (*-2LL*) coefficient comparisons of this model and the previous null model, were used to estimate whether significant additional variance in post alphabet knowledge scores was accounted for by participation in CtC. The difference between the null model (*-2LL* = 953.56) and the model adding participation in CtC as a predictor (*-2LL* = 926.64) was significant, $\chi 2$ (1) = 26.92, p < .01. There was a change in R^2 of .24 for post-intervention alphabet knowledge scores when participation in CtC was entered into the model. Therefore, participation in CtC accounted for significant proportion of variance in post-intervention alphabet knowledge scores after accounting for the influence of SES.

Pre-test alphabet knowledge scores were then added as a fixed predictor to the model. Pre-test alphabet knowledge scores accounted for a significant proportion of variance in post-test alphabet knowledge scores, F (1, 96) = 165.73, $p < .001$, $-2LL$ = 830.37 (Δ-$2LL$ = 96.27), ΔR^2 = .63. Participation in CtC remained a significant predictor after pre-test alphabet knowledge scores were accounted for, F (1, 96) = 37.07, $p < .001$.

Short term memory scores were next added as a fixed predictor to the model. Short term memory scores were not significant in accounting for a significant proportion of variance in post-test alphabet knowledge scores, F (1, 96.04) = 1.22, p = .272, $-2LL$ = 829.16 (Δ-$2LL$ = 1.21), ΔR^2 = .12. Participation in CtC remained a significant predictor after short term memory scores were accounted for, F (1, 96) = 38.01, $p < .001$.

In the final model, oral language scores were entered as a fixed predictor, to control for language differences in the estimation of CtC's influence on post-test scores. Oral language scores did not account for a significant proportion of variance in post-test alphabet knowledge scores, F (1, 96.56) = .87, p = .354, $-2LL$ = 828.30 (Δ-$2LL$ = 0.86), ΔR^2 = .07. Participation in CtC remained a significant predictor after oral language scores were accounted for, F (1, 96.02) = 38.99, $p < .001$. The change from the baseline model to the final model (as shown in Table 8) is significant ($p <$ .001), indicating that the final model, inclusive of all parameters explains a significant amount of variance in post-intervention alphabet knowledge scores.

In summary, participation in the CtC program showed significant improvement in post-intervention alphabet knowledge scores after controlling for potentially confounding variables. This finding therefore supports Hypothesis 2, that the Cracking the Code intervention program was effective in increasing the alphabet knowledge of participants.

Table 8

Post Letter Name and Sound Scores - Final Multilevel Model

Parameter	Model 1	Model 2	Model 3	Model 4	Model 5
Level 2					
SES	97.33	36.50*	0.27	0.67	1.44
	(0.01)	(0.007)	(0.634)	(0.416)	(0.233)
Level 1					
Participation in CtC		31.07*	37.08*	38.01*	38.99*
		(<0.001)	(<0.001)	(<0.001)	(<0.001)
Pre Total Letter Name			165.73*	135.62*	111.37*
and Sound Score			(<0.001)	(<0.001)	(<0.001)
Short Term Memory				1.22	0.71
				(0.272)	(0.400)
Oral Language					0.87
					(0.354)

Note: SES = Index of Relative Socio-Economic Advantage and Disadvantage, Short Term Memory = ERB Pre-School Repetition Subtest, Oral Language = CELF P2 Core Language Score

3.3.2 Follow up moderation analyses. The relationship between participation in CtC and post-test alphabet knowledge scores was examined. Whether this relationship was conditional on pre-test alphabet knowledge scores, while controlling for the influence of short term memory, oral language and SES, was also investigated. A moderation analysis showed the effects of participation in CtC on post-test alphabet knowledge scores were not conditional on participants' pre-intervention alphabet knowledge scores, F (1, 91) = .01, p = .910, ΔR^2 = <.001. A subsequent moderation analysis was performed to examine whether the influence of participation in CtC on post-intervention alphabet knowledge was conditional on the participants' short term memory after controlling for SES, oral language and pre-intervention alphabet knowledge scores. Again, short term memory did not provide a conditional influence on the relationship between CtC participation and post-intervention alphabet knowledge scores F (1, 91) = .01, p = .337 ΔR^2 = .003. Therefore the improvements seen in alphabet knowledge as a result of participation in the Cracking the Code program, were not conditional on pre-test alphabet

knowledge scores or short term memory. These results indicate that the efficacy of the program in improving alphabet knowledge, is not dependent on pre-test scores.

3.4 Intervention and Non-Word Reading

3.4.1 Multilevel modelling. Prior to analysis, nine extreme univariate outliers were removed, and the pre non-word reading score variable was algebraically transformed to improve univariate normality. All remaining assumptions as outlined in the prior analysis were met prior to the forthcoming analysis**.**

To explain the variance in post non-word reading scores accounted for by the predictors within the model, a hierarchical model was constructed. The random effect of SES was included as a level two variable. The level one fixed predictor variables (participation in CtC, pre non-word reading scores, short term memory scores and oral language scores) were added to subsequent models in the above order. Model fit change was evaluated against a critical chi square value of of $\alpha = .01$ (Field, 2013).

Within the null model of the hierarchical analysis, SES was not shown to significantly predict post non-word reading scores, F (1, 2) = 20.05, p =.046. The intra-class correlation coefficient (ICC) was used to calculate the proportion of the total variability in the outcome that was attributed to SES differences. Calculations showed 10.89% of variance was accounted for by these differences, which is noteworthy and thus again reinforces the value of a multilevel analysis approach, as the higher level predictor accounted for over 5% of the variance in the outcome variable (Heck, Thomas, & Tabata, 2014).

Within the second model, participation in CtC was entered as a fixed predictor, while controlling for the effects of SES. Participation in CtC significantly predicted post-intervention non-word reading scores F (1, 93) = 46.66, $p < .001$. A difference between the null model ($-2LL$ = 716.68) and the model adding CtC participation as a predictor ($-2LL$ = 678.88) was significant, $\chi 2$ (1) = 37.80, $p < .01$. A change in R^2 of .33 for post-intervention non-word reading scores, or approximately 33%, was indicated when the CtC participation predictor was entered into the model. Participation in CtC therefore accounted for significant variance in post-intervention non-word reading scores after accounting for the influence of SES.

In the following model, pre-test non-word reading scores accounted for a significant proportion of variance in post-test non-word reading scores F (1, 93) = 35.11, $p < .001$, $-2LL$ = 649.08 ($\Delta -2LL$ = 29.80), ΔR^2 = .27. Participation in CtC

remained a significant predictor after pre-test non-word reading scores were accounted for, F (1, 93) = 43.91, $p < .001$.

Short term memory scores were added as a fixed predictor to the model in the next analysis. Short term memory scores were significant, F (1, 93) = 11.93, p = .001, $-2LL$ = 637.86 ($\Delta -2LL$ = 11.22), ΔR^2 = 0.11. Participation in CtC remained a significant predictor after short term memory scores were accounted for, F (1, 93) = 50.36, $p < .001$.

Oral language scores were entered as a fixed predictor in the final model. Oral language scores did not account for a significant proportion of variance in post-test non-word reading scores, F (1, 93.15) = 5.82, p = .018, $-2LL$ = 632.21 ($\Delta -2LL$ = 5.65), ΔR^2 = .06. Participation in CtC remained a significant predictor after oral language scores were accounted for, F (1, 93) = 57.82, $p < .001$. The model fit change from the baseline model to the final model (as shown in Table 9) is significant, indicating that the final model, inclusive of all parameters explains a significant amount of variance in post-intervention non-word reading scores.

In summary, participation in CtC demonstrated significant improvement in post-intervention non-word reading scores after controlling for potentially confounding variables. This finding therefore supports Hypothesis 3a, that the Cracking the Code intervention program was effective in increasing the non-word reading scores of participants.

Table 9

Post Non-Word Reading Scores - Final Multilevel Model

Parameter	Model 1	Model 2	Model 3	Model 4	Model 5
Level 2					
SES	20.05	5.16	1.90	6.14	11.80*
	(0.046)	(0.131)	(0.283)	(0.017)	(0.001)
Level 1					
Participation in CtC		46.66*	43.91*	50.36*	57.82*
		(<0.001)	(<0.001)	(<0.001)	(<0.001)
Pre Non-Word Reading			35.11*	27.35*	23.28*
Score			(<0.001)	(<0.001)	(<0.001)
Short Term Memory				11.93*	6.91
				(0.001)	(0.010)
Oral Language					5.82
					(0.018)

Note: SES = Index of Relative Socio-Economic Advantage and Disadvantage, Short Term Memory = ERB Pre-School Repetition Subtest, Oral Language = CELF P2 Core Language Score

3.4.2 Follow up moderation analyses. The relationship between participation in CtC and post-test non-word reading scores was examined. Specifically, whether this relationship was conditional on pre-test non-word reading scores when controlling for the influence of short term memory, oral language and SES. A moderation analysis showed the effects of participation in CtC on post-test non-word reading scores were not conditional on participants' pre-intervention non-word reading scores, F (1, 88) = .001, p = . 980, ΔR^2 < .001. An additional moderation analysis was conducted to examine whether the influence of CtC participation on post-intervention non-word reading, was conditional on the participants' short term memory after controlling for SES, oral language and pre-intervention non-word reading scores. As with pre-test non-word reading scores, short term memory did not provide a conditional influence on the relationship between participation in CtC and post-intervention non-word reading scores F (1, 88) = 0.10, p = . 757, ΔR^2 < .001.

Therefore, the improvements seen in non-word reading as a result of participation in the Cracking the Code program, were not conditional on pre-test

non-word reading scores or short term memory. These results indicate that the efficacy of the program in improving non-word reading is not dependent on pre-test scores.

3.5 Intervention and Non-Word Spelling

3.5.1 Multilevel modelling. Prior to analysis, nine extreme univariate outliers were removed, and the pre non-word spelling and post non-word spelling variables were algebraically transformed to improve univariate normality. All remaining assumptions as outlined in the prior analysis were met prior to the forthcoming analysis**.**

Within the null model of the hierarchical analysis, SES was not shown to significantly predict post non-word spelling scores, F (1, 2) = 34.25, p = .018. The intra-class correlation coefficient (ICC) calculations showed 5.91% of the total variability was accounted for by SES differences.

Within the second model, participation in CtC was entered as a fixed predictor, while controlling for the effects of SES. Participation in CtC significantly predicted post-intervention non-word spelling scores F (1, 93.01) = 10.35, p = .002. A difference between the null model (-*2LL* = 387.01) and the model adding CtC participation as a predictor (-*2LL* = 377.20) was significant, $\chi 2$ (1) = 9.82, $p < .01$. When the participation in CtC predictor was entered into the model, a change in R^2 of .10 for post-intervention non-word spelling scores, or approximately 10%, was indicated. Participation in CtC therefore accounted for significant variance in post-intervention non-word spelling scores after accounting for the influence of SES.

In the following model, pre-test non-word spelling scores accounted for a significant proportion of variance in post-test non-word spelling scores, F (1, 93.01) = 14.60, $p < .001$, -*2LL* = 363.62 (Δ-*2LL* = 13.57), ΔR^2 = .135. The participation in CtC variable remained a significant predictor after pre-test non-word spelling scores were accounted for, F (1, 93) = 8.01, p = .006.

Short term memory scores were added as a fixed predictor to the model in the next analysis. Short term memory scores were significant, F (1, 93) = 13.98, $p <$ .001, -*2LL* = 350.60 (Δ-*2LL* = 13.03), ΔR^2 = 0.13. The participation in CtC variable remained a significant predictor after short term memory scores were accounted for, F (1, 93) = 8.78, p = .004.

Oral language scores were entered as a fixed predictor in the final model. Oral language scores did not account for a significant proportion of variance in post-test

non-word spelling scores, F (1, 93.45) = 6.07, p = .016, *-2LL* = 344.72 (Δ*-2LL* = 5.87), ΔR^2 = .06. The participation in CtC variable remained a significant predictor after oral language scores were accounted for, F (1, 93) = 10.93, p = .001. The model fit change from the baseline model to the final model (as shown in Table 10) is significant, indicating that the final model, inclusive of all parameters explains a significant amount of variance in post-intervention non-word spelling scores.

This finding therefore supports hypothesis 3b. Participation in the CtC program demonstrated significant improvement in post-intervention non-word spelling scores after controlling for potentially confounding variables.

Table 10

Post Non-Word Spelling Scores - Final Multilevel Model

Parameter	Model 1	Model 2	Model 3	Model 4	Model 5
Level 2					
SES	34.25	15.72	11.13	6.74	12.68*
	(0.028)	(0.029)	(0.042)	(0.011)	(0.001)
Level 1					
Participation in CtC		10.35*	8.01*	8.78*	10.93*
		(0.002)	(0.006)	(0.004)	(0.001)
Pre Non-Word Spelling			14.60*	8.03*	8.47*
Score			(<0.001)	(0.006)	(0.005)
Short Term Memory				13.98*	7.82*
				(<0.001)	(0.006)
Oral Language					6.07
					(0.016)

Note: SES = Index of Relative Socio-Economic Advantage and Disadvantage, Short Term Memory = ERB Pre-School Repetition Subtest, Oral Language = CELF P2 Core Language Score

3.5.2 Follow up moderation analyses. The relationship between participation in CtC and post-test non-word spelling scores, and whether this relationship was conditional on pre-test non-word spelling scores, while controlling for the influence of short term memory, oral language and SES was examined. A moderation analysis showed the effects of participation in CtC on post-test non-word spelling scores were not conditional on participants' pre-intervention non-word spelling scores, F (1, 88)

= .54, p = . 464, ΔR^2 = .004. A subsequent moderation analysis was conducted to examine whether the influence of participation in CtC on post-intervention non-word spelling was conditional on the participants' short term memory after controlling for SES, oral language and pre-intervention non-word spelling scores. Short term memory similarly did not provide a conditional influence on the relationship between participation in CtC and post-intervention non-word spelling scores, F (1, 88) = 2.96, p = . 088, ΔR^2 = .019. Therefore the improvements seen in non-word spelling as a result of participation in the Cracking the Code program, were not conditional on pre-test non-word spelling scores or short term memory. These results indicate that the efficacy of the program in improving non-word spelling, is not dependent on pre-test scores.

3.6 Summary

In summary, a series of multilevel modelling analyses found that participation in CtC contributed significantly to gains made in phonological awareness, alphabet knowledge, non-word reading and non-word spelling after controlling for SES, pre-test scores, short term memory and oral language capabilities. A summary of these findings can be found in table 11.

Table 11

Summary of Hypotheses

Hypothesis	Outcome
H1: Cracking the Code (CtC) will improve the phonological awareness skills of kindergarten students (kindergarten age range: 3;6-5;6).	Supported
H2: The Cracking the Code program will improve the alphabet knowledge skills of kindergarten students (kindergarten age range: 3;6-5;6).	Supported
H3a: The Cracking the Code program will improve the non-word reading skills of kindergarten students (kindergarten age range: 3;6-5;6).	Supported
H3b: The Cracking the Code program will improve the non-word spelling skills of kindergarten students (kindergarten age range: 3;6-5;6).	Supported
H4: The effectiveness of the Cracking the Code program will be influenced by participants' oral language and short term memory capabilities. Specifically, children with stronger oral language and short term memory skills will show greater responsiveness to the Cracking the Code program.	Not Supported

4. Discussion

The purpose of this study was to evaluate the effectiveness of a classroom delivered phonological awareness and alphabet knowledge teaching program for children in kindergarten in Western Australia, in the age range of 3;6-5;6 years. This program was designed to take into account key parameters raised in the literature and is of *short duration, and low intensity*, and integrates instruction across a *broad* range of phonological awareness skills with an emphasis on phonemic awareness. It uses explicit and developmentally appropriate teaching practices. A pre-test post-test

parallel groups design was used. Schools were randomly assigned to the control or experimental condition. Schools in the experimental group participated in the Cracking the Code program (18 weeks of intervention consisting of 36 sessions each lasting for 55 minutes), and schools in the control group participated in the Words, Grammar and Fun program (18 weeks of intervention consisting of 36 sessions each lasting for 20 minutes). The results supported our primary hypotheses that participation in the experimental intervention (Cracking the Code) would result in significant gains in phonological awareness, alphabet knowledge, non-word reading and non-word spelling. The hypotheses will now be discussed in turn, beginning with the broad findings of this study followed by more detailed exploration of the findings with reference to the literature, and the practical implications.

4.1 Cracking the Code and Phonological Awareness

The first hypothesis proposed that Cracking the Code (CtC) would improve the phonological awareness skills of kindergarten students aged between 3;6 and 5;6. Participants in the experimental group made significantly more gains in phonological awareness than the control group by the end of the intervention period, thus supporting the effectiveness of this program. This finding also supports the conclusions of the National Reading Panel's meta-analysis (2000) of a large effect size on phonological awareness outcomes in response to phonological awareness instruction, indicating that these skills can be successfully taught with high quality intervention.

The pre intervention mean phonological awareness score on the Cracking the Code Phonological Awareness Assessment (CTCPAA) for the experimental group was 25.53/190 and the mean post score was 80/190, which did not approach ceiling. It is important to note that due to the linguistic and task complexity of the subtests included in the assessment, a kindergarten aged child would not be expected to achieve a full score on the CTCPAA assessment. According to the Kindergarten Curriculum Guidelines (SCSA, 2015), kindergarten children aged between 3;6 and 5;6 years are expected to be able to identify syllables within words, explore onset-rime skills, discriminate rhyming words and demonstrate emerging awareness of initial and final sounds in simple consonant-vowel-consonant words. Competence in these expected skills would yield a score between 45 and 60 on the CtC Phonological Awareness Assessment. This illustrates the overall appropriate, and in many instances higher, level of expected development achieved after the intervention by

the experimental group in this study according to the Kindergarten Curriculum Guidelines (2015) released by the School Curriculum and Standards Authority.

While there is differing opinion and evidence in the literature about the exact ages at which phonological awareness skills can be acquired, the findings of the current study add support to the argument that children of a younger age (3;8 -5;4 year olds) are able to make significant gains in syllable, onset-rime and phoneme level phonological awareness following targeted explicit teaching, and gives strength to the argument for the introduction of these skills in kindergarten. These findings differ from older studies (e.g. Liberman, 1974) which reported the development of onset-rime and phoneme awareness at around 6 years of age. However, they are consistent with more recent research which has demonstrated that explicit teaching yields earlier phonological awareness (onset-rime and phoneme level) skills (e.g. Ehri, Nunes, Willows, Schuster, Yaghoub-Zadeh & Shanahan, 2001). The findings of this study support the early acquisition of phonological awareness skills in response to explicit instruction. Other studies have investigated children's phonological awareness outcomes in response to phonological awareness intervention, although most have been conducted with older age groups (e.g. Ehri, Nunes, Willows, Schuster, Yaghoub-Zadeh & Shanahan, 2001; Nancollis, Lawrie & Dodd, 2005). The outcomes of this preliminary local effectiveness study thus support the introduction of the teaching of phonological awareness at the earliest stage of schooling, which in Western Australia, is kindergarten, using an evidence based approach such as CtC.

Furthermore, drawing on evidence supporting the development of phonological awareness skills at a younger age allows scope for the provision of critical earlier intervention (Burke, Hagan-Burke, Kwok & Parker, 2009). This is particularly important as children who present with deficits in phonological awareness in their early years often continue to have persistent difficulties, in particular if not provided with appropriate and explicit intervention (Moore, Evans & Dowson, 2005).

The findings reported here also add to the research base supporting the effectiveness of small group phonological awareness instruction in a classroom setting, which is not well documented in the literature. This model of service delivery is in contrast to the use of a more specialised pull-out model more typically investigated in the larger body of efficacy research (e.g. Ehri et al., 2001; Gillon, 2005a; Gillon, 2000). A pull-out model is less feasible in schools as it is generally

more expensive with regards to both time and resources. Thus the findings of this study have educational implications for the teaching of phonological awareness in classrooms by teachers to a wider range of students. Specifically, it shows that a classroom based program (CtC) can be used to assist in effective curriculum teaching to develop phonological awareness skills.

With regards to duration and intensity of effective phonological awareness instruction, the findings of this study show that a short duration (less than one year), low intensity (less than 2 hours per week), and broad program (focussing on a range of phonological awareness skills) is effective in producing immediate gains. These results are consistent with those reported by Fuchs et al. (2001) and Justice et al. (2010). Justice and colleagues (2010) investigated the development of phonological awareness skills in children aged between 3;3 and 5;6, in response to phonological awareness intervention. While this age range is similar to that of the current study, the total instructional time was less (10-15 hours as compared to 24 hours in CtC).

While there are differences between the programs used in these studies and CtC, they all meet the criteria of being short duration, low intensity and broad. Therefore, based on the research literature it was expected that within the current study, children in the experimental group would perform significantly better than those in the control group after being exposed to the intervention parameters in CtC, a program of short duration (18 hours) which was 'low intensity' but nevertheless of a higher intensity (more instructional time per week). CtC provides 80 minutes of phonological awareness intervention per week (24 hours in total instructional time) as compared to 20 – 45 minutes of intervention per week (10-15 hours instructional time in total) (Fuchs et al., 2001; Justice et al., 2010). The positive results of the current study thus support the importance of high quality and frequent classroom instruction (Elbaum, Vaughn, Hughes, & Moody, 1999; Gillon, 2004), along with the findings of Justice and colleagues (2010), that a short duration, low intensity program can yield significant gains in phonological awareness.

While Carson, Gillon and Boustead (2013) reported positive outcomes with sustained gains, from a short duration (10 weeks, 20 hours of instruction), narrow program (focussing on phoneme and onset-rime levels) with children aged between 5;0-5;2, the current study targeted children as young as 3;8. Participants in the Carson et al. study, both experimental and control groups, also engaged in formal literacy instruction, five days per week. This is consistent with the New Zealand

curriculum, and includes guided reading and shared reading. The participants in the current study in Western Australia, were also engaged in literacy instruction as part of the usual curriculum, however, this was not part of a formal program. Participants in the current study also attended only two and a half days of formal schooling each week. In addition, different parameters were used in the CtC program which was of short duration (18 weeks, 24 hours of instruction) but was broad in focus (targeting syllable, onset-rime and phoneme level), and which resulted in significant and positive phonological awareness outcomes in this younger population. Although a narrow focus has usually been associated with positive change, due to the younger age of the children in the study, and the developmental trajectory of phonological awareness, the broad focus allowed earlier developing skills to be included in the program. It may be then hypothesised that these younger participants benefited from the similar intensity of instruction, while the broad instruction as provided within CtC may allow development of earlier phonological awareness skills (i.e. syllable and onset-rime), prior to progressing to phonemic awareness.

These results contribute to a greater understanding of the parameters of an effective classroom based, teacher implemented program. They provide evidence to support that a short duration program (18 weeks), which is low intensity (80 minutes per week of phonological awareness instruction), and focuses on a broad range of skills (syllable, onset-rime and phoneme), is effective in significantly increasing the phonological awareness skills of students aged 3;8-5;4. This study provides support that these outcomes are achievable using the above parameters in a heterogeneous classroom environment (Carson, Gillon & Boustead, 2013).

Cracking the Code focussed on syllable and onset-rime as well as phoneme level phonological awareness skills. Close inspection of the data (reported in Table 4), illustrates that while gains were made at all levels, gains at the phoneme level were the most noteworthy difference between control and experimental groups. These results suggest that the phoneme level awareness intervention was highly effective, providing further evidence to support the inclusion of phoneme level blending and segmentation skills in explicit phonological awareness instruction, even within this younger age group (3;8 – 5;4). This is particularly important given the research (e.g. Carson, Gillon & Boustead, 2013, Share, Jorm Maclean, Matthews, 1984), linking phonemic awareness, in particular blending and segmenting of phonemes, to improved reading and spelling outcomes. This body of research paired

with the results of the current study indicates that the CtC program is effective in improving skills which support the development of reading and spelling.

Teacher training was another important element outlined in the literature as requiring more investigation (Assel, Landry, Swank & Gunnewig, 2007; McLachlan & Arrow, 2010; Schuele & Bordreau, 2008). Cracking the Code includes the provision of professional learning for teaching staff, modelling of phonological awareness activities by a speech pathologist and the provision of comprehensive task administration instructions. Professional learning sessions and modelling of activities aimed to increase the knowledge and skills of teachers and education assistants involved in running the CtC program. This training component is suggested to be vital as studies such as Washburn, Binks-Cantrell, Joshi, Martin-Chang and Arrow (2015) and, Aro and Bjorn (2015) report that both pre-service and in-service teachers lack knowledge in the area of phonological awareness and in particular phonemic awareness. The results of this study reported here provide evidence to support the effectiveness of this professional learning and modelling in yielding significant phonological awareness outcomes.

4.2 Cracking the Code and Alphabet Knowledge

The second hypothesis predicted that Cracking the Code would improve the alphabet knowledge skills of the participants. Participants in the experimental group made significant gains in alphabet knowledge by the end of the intervention period, when compared to the control group.

The mean alphabet knowledge score for the experimental group post intervention was 33.14/52 for letter name and 31.7/52 for letter sound. Again it is important to note that according to the Kindergarten Curriculum Guidelines (SCSA, 2015), kindergarten children aged between 3;6 and 5;6 years are expected to be able to "recognise some letter names, for example the letters in their name". This would suggest that, as with phonological awareness, following participation in CtC, the children are performing at the level consistent with or above the curriculum guidelines.

Gains seen in the experimental group when compared to the control group suggest that explicit teaching of the alphabet is successful in eliciting significant gains, and supports this teaching within a literacy program, findings which are consistent with other research (Ehri & Roberts, 2006; Foorman, Anthony, Seals & Mouzaki 2002; Gallagher et al., 2000; Whitehurst & Lonigan, 2002). Gains in scores

were seen for both letter names and sounds which adds to the small body of research investigating the effectiveness of teaching both (Evans, Bell, Shaw, Moretti & Page, 1996; Gillon, 2005a). Larger gains were seen in the improvement of letter sounds when compared with improvements in letter names, which is again consistent with the literature and supports the argument for letter name to sound facilitation, including the principle that letter names provide cues for learning letter sounds (Evans et al., 2006; Share, 2004). These results indicate that the inclusion of both letter name and sound instruction as part of CtC was worthwhile.

The results of this study provide support for the use of intensive classroom based alphabet letter-sound instruction (30 minutes per week, 9 hours in total) over an 18 week period, provided in conjunction with phonological awareness instruction, to improve the alphabet knowledge (name and sound) of kindergarten students.

4.3 Cracking the Code and Non-Word Reading and Spelling

The third hypotheses predicted that Cracking the Code would improve the non-word reading and non-word spelling skills of the participants, demonstrating the transfer of skills from sound to print. Participants in the experimental group made significantly more gains in both non-word reading and spelling by the end of the intervention period, when compared to the control group.

The mean scores for the experimental group post intervention were 19.08/40 for non-word reading and 11.82/30 for non-word spelling. The Kindergarten Curriculum Guidelines (SCSA, 2015), contain no requirements for encoding or decoding tasks (beyond "using approximations of letters and words to convey meaning") for kindergarten children aged between 3;6 and 5;6 years. This would suggest that while the non-word reading and spelling scores achieved by the children in the experimental group were in the low range, they are at least consistent with, or exceed expectations of the Kindergarten Curriculum Guidelines (SCSA, 2015).

Phonological awareness is widely reported in the literature as having strong links to reading and spelling development (Gillon, 2005b; National Reading Panel, 2000). This study provides further evidence to support this link and is consistent with the results from the National Reading Panel's (2000) meta-analysis which reported that phonological awareness instruction yielded moderate to large effect sizes on phonological awareness and reading and spelling outcomes, specifically on measures of reading both real and non-words.

In the current study, children in the experimental group, who on average had higher phonological awareness scores post intervention than the control group, were also better at non-word reading and spelling post intervention which supports the predictive relationship between these skills. Bradley and Bryant (1983) found that the phonological awareness skills of 4-5 year olds was the strongest predictor of reading and spelling in 7-8 year olds, while MacDonald and Cornwall (1995) reported that it was also a reliable predictor of spelling ability over an 11 year period. These results suggest that intervention at the early age of 3;8 – 5;4 years is effective in eliciting immediate gains, as measured by the non-word reading and spelling tasks. However, research including longer term follow-up is required to assess maintenance of such growth, and further strengthen the evidence.

The results of this study demonstrate that phonological awareness and alphabet knowledge instruction can lead to improvement in non-word reading and spelling, not taught directly in the CtC program. While these results are consistent with findings from Gallagher et al. (2000) which reports significant associations between poor letter name and sound knowledge, and later reading difficulties in children with a mean age of 3;8, they were not consistent with the findings of Piasta and Wagner's (2010) meta-analysis, which was inconclusive in finding a link between alphabet knowledge and reading and spelling. There are a range of factors that may explain this difference, including that most studies in the meta-analysis did not include focussed alphabet knowledge instruction, whereas CtC included 540 minutes of devoted alphabet knowledge instructional time. Many studies included in the meta analysis also provided either phonological awareness instruction or an alternative form of alphabet instruction to the control group. Neither of these were provided to the control group in the current study which may have impacted the results. Finally, another potential explanation for this finding is that most studies in the meta-analysis did not include instruction which focussed on the contextual use of alphabet knowledge within whole word reading and spelling tasks, which is an element of CtC in later stages of the program. These may all be valid reasons as to why the results of this current study were significant and not concurrent with the results of the meta-analysis. CtC first focuses on explicitly teaching phonological awareness and alphabet knowledge separately, and consolidation of these skills before combining phonological awareness with alphabet knowledge in order to represent sounds heard with written symbols, thus explicitly teaching the alphabetic principle.

In sum, the findings of this study add to the body of research which shows that gains in phonological awareness and alphabet knowledge, and the teaching of these skills in combination transfer to the early developing skills of decoding and encoding.

4.4 Responsiveness to Treatment

The fourth hypothesis predicted that stronger oral language and short term memory skills would be associated with increased responsiveness to the Cracking the Code program. Given that CtC was shown to be effective in developing phonological awareness, alphabet knowledge, non-word reading and non-word spelling scores in this cohort of kindergarten children aged 3;8-5;4, it is important to explore issues such as responsiveness to intervention, as addressed by the fourth hypothesis. The use of multilevel modelling followed by moderation analyses allowed exploration of these factors.

4.4.1 Phonological awareness. While pre-test phonological awareness scores did account for a significant amount of variance in post-test phonological awareness scores, as expected, moderation analyses showed that improvement in post phonological awareness scores was not dependent on pre scores, indicating that all participants responded equally as well to the program. These findings demonstrate the effectiveness and thus the utility of CtC for a range of children, irrespective of their initial level of performance.

The significant results of this study add to the small body of research available that has investigated the phonological awareness development of students within this younger age group (3;6-5;6 years) – in both typically developing and 'at risk' students. The current research study found that 24 hours of phonological awareness intervention was effective in significantly increasing the skills of children presenting with a broad range of initial abilities regardless of pre-test phonological awareness scores. This differs from results reported by Ukrainetz and colleagues (2009) which found that 10-20 hours of intervention was successful in producing a significant increase in the phonological awareness skills of children (aged 5-6) with mild deficits, but the same level of increase was not seen for those children initially presenting with moderate deficits. So while it may have been expected that children with a moderate phonological awareness impairment would be less responsive to the CtC program, the results of the current study suggest that 24 hours of phonological

awareness intervention (as provided within CtC) was effective in producing significant gains across a broad range of participants .

As such it would appear that the increased instructional time may have contributed to the increase in skills seen across all children regardless of initial phonological awareness abilities (mild or moderate delay) as all children responded equally as well to the program.

The short term memory scores of participants were a significant predictor of their post intervention phonological awareness scores, consistent with the literature investigating links between phonological awareness and short term memory (Baddeley, 2003; Baddeley, Gathercole & Papagno, 1998; Gillam & van Kleeck, 1996). However, while children presenting with poorer short term memory also generally presented with lowered post-test phonological awareness scores, moderation analysis results suggested that participants' actual improvements in post-test phonological awareness scores did not vary based on short term memory scores. Again, children with low and high performance scores benefitted equally from the program. This is consistent with the study carried out by Gillam and van Kleeck (1996), who reported that children with strong phonological working memory were no more responsive to phonological awareness instruction than children with weaker phonological working memory abilities.

Oral language capabilities did not affect phonological awareness outcomes, which was not consistent with the literature (Cooper, Roth , Speece & Schatschneider, 2002; Snow, Eadie, Connell, Andersen, McCusker & Munro, 2014). This may be due to the measures used to assess oral language in this study. Core language subtests from the CELF-P2 were used as the oral language measure. The CELF-P2 composite score is based on comprehension of sentence structure, expressive word level morphology and grammar, and expressive vocabulary. Expressive vocabulary is the domain most widely researched in the area, as the fine phonological discriminations and differentiations required for storage of an increasing number of lexical items are also said to support the development of phonological awareness (Evans, Bell, Shaw, Moretti & Page, 2006). While much of the research has drawn heavily on vocabulary measures, the present study used a more comprehensive measure of language which subsumed vocabulary within a composite language score. This may have influenced the lack of relationship between oral language and the responsiveness to treatment seen in this study.

Justice et al. (2010) found that children (aged between 3;3-5;6) with language difficulties were less responsive to phonological awareness intervention than children with typically developing language. Again, the results of the current study are not consistent with these findings. However, CtC's total instructional time is longer in duration, 24 hours in total as compared with 10-15 hours in Justice et al. (2010), and CtC's sessions are also less dispersed, delivered over an 18 week period as opposed to the 30 week period in Justice et al. (2010). The increased and more concentrated delivery of the intervention may explain the effectiveness of CtC in producing significant changes across all children regardless of initial language ability. Further investigation of these intervention parameters will be useful in understanding the roles of duration, frequency and intensity in treatment outcomes.

The results of the current study indicate that all the children in this cohort, regardless of oral language abilities, responded equally as well to CtC with regards to improvement in their phonological awareness skills. This supports the teaching of phonological awareness skills in a mainstream classroom environment where there would be a broad range of language skills.

4.4.2 Alphabet knowledge. Pre-test alphabet knowledge scores accounted for a significant amount of variance in post-test scores. Moderation analyses showed that improvement in post-test alphabet knowledge scores were not dependent on pre-test scores, indicating that all participants responded equally as well to the program. These findings were consistent with those from Piasta and Wagner's (2010) meta-analysis and indicate that the program is effective for a range of children, irrespective of their initial level of performance.

In sum, short term memory did not have a significant influence on alphabet knowledge outcomes, nor did or oral language capabilities, indicating that the program is effective for a large range of children.

4.4.3 Non-word reading and spelling. Pre-test non word reading and spelling scores accounted for a significant proportion of variance, indicating that generally participants who were better at non-word reading and spelling prior to the intervention phase were also better post intervention, which is to be expected. Importantly, moderation analyses showed that participants' improvements in post-test non-word reading and spelling scores did not vary based on pre-test scores, indicating that all participants responded equally as well to the program. Thus, the

program was effective for a range of children irrespective of their initial reading and spelling performance.

Short term memory accounted for a significant proportion of variance in non-word reading and non-word spelling scores, indicating that children with short term memory difficulties also had more difficulty with non-word reading and spelling tasks. This is supported by the theoretical links between the phonological loop (a component of short term memory) which is theorised to be responsible for the rehearsal and retention of verbal phonological information, and spelling and new word learning (Baddeley, 2003). This is also consistent with reports that phonological working memory is correlated with a number of skills including comprehension, vocabulary, metalinguistic skills and decoding (reading) skills (Gillam & Van Kleeck,1996). Nevertheless, improvements in post-test non-word reading and spelling scores did not vary based on short term memory scores, indicating that while some participants found these tasks more difficult, they all made similar non-word reading and spelling improvements in response to the program, irrespective of short term memory scores.

Finally, oral language did not have a significant influence on non-word reading or non-word spelling indicating that the program is effective for a range of children regardless of initial language abilities. These results are consistent with McCarthy, Hogan and Catts (2012) who investigated the links between oral language and spelling in children with specific language impairment and/or dyslexia when compared with typically developing peers. Participants were of kindergarten age (which begins at age 5 in the U.S.) at the commencement of the study and were then re-assessed in fourth grade. Results of this study indicated that oral language scores in kindergarten, as measured by the TOLD-P:2 (Newcomer & Hammill, 1998) were not a significant predictor of spelling abilities in fourth grade as measured by the Test of Written Spelling – 3rd Ed (Larsen & Hammill, 1994). In sum, oral language did not have a significant influence on non-word reading or non-word spelling outcomes, indicating that the program is effective for a large range of children.

4.5 Limitations and Follow Up Studies

This study demonstrated the effectiveness of a teacher implemented phonological awareness and alphabet knowledge program. However, the research environment, being a heterogeneous classroom environment raised some issues with treatment fidelity. Such issues included factors related to consistency of

implementation by education staff, knowledge of education staff and participant absences during the duration of the intervention phase. Fidelity was addressed in this study through the use of clear implementation and dosage guidelines, the use of activity instruction cards, provision of training and modelling support to education staff and maintaining records of activity implementation. A future study would benefit from the provision of additional modelling sessions to increase consistency of implementation, the collection of pre and post measures of education staff knowledge (phonological awareness and alphabet knowledge) and the collection of absenteeism data for all participants.

In addition, while participants in the control condition participated in a similarly structured intervention program, the (control) WGF program included shorter sessions and therefore a reduced overall instruction time when compared with CtC. While it is unlikely that increased instruction in grammar and semantics would have resulted in improved phonological awareness, alphabet knowledge and non-word reading and spelling skill, ideally participants in both conditions would have received the same amount of instructional time over the intervention period. A future study would therefore match the intervention programs used in the experimental and control conditions with regards to weekly instructional time.

Given that all schools included in the study had decile IRSAD scores of nine and ten, as they were originally selected on the basis of these similar scores to control for SES differences, there was a narrow range of school IRSAD scores included in the current study. This is a limitation of the current study, as a broader range of schools with a broader range of IRSAD scores would have provided research outcomes regarding the effectiveness of the program for a broader socio-economic range of children. Future studies should therefore include more schools to allow for examination of a broader range of IRSAD scores, while maintaining the matched design.

While this study also looked at immediate gains across the areas of phonological awareness, alphabet knowledge, non-word reading and non-word spelling, a follow up study would be beneficial in order to look at maintenance and sustained gains across all areas. This would involve planned maintenance testing of phonological awareness and alphabet knowledge and follow up testing of reading and spelling skills. Other studies, such as Fuchs et al. (2001) and Justice et al. (2010), which investigated the effectiveness of phonological awareness programs with the

same classification as CtC (short, low intensity and broad) suggest that these programs yield immediate but not sustained gains. It remains to be seen if the gains obtained from CtC are sustained in the longer term.

4.6 Summary

In sum, this study has shown that phonological awareness and alphabet knowledge can be taught to 3;8 – 5;4 year olds using an explicit teaching approach, and that this results in improved non-word spelling and reading. In addition, the program can be effectively delivered by education staff following training, supporting high quality classroom based instruction. The findings of this study therefore provide support for the effectiveness of the Cracking the Code Program, small group instruction in a heterogeneous classroom environment, for children with a range of abilities delivered within a school setting.

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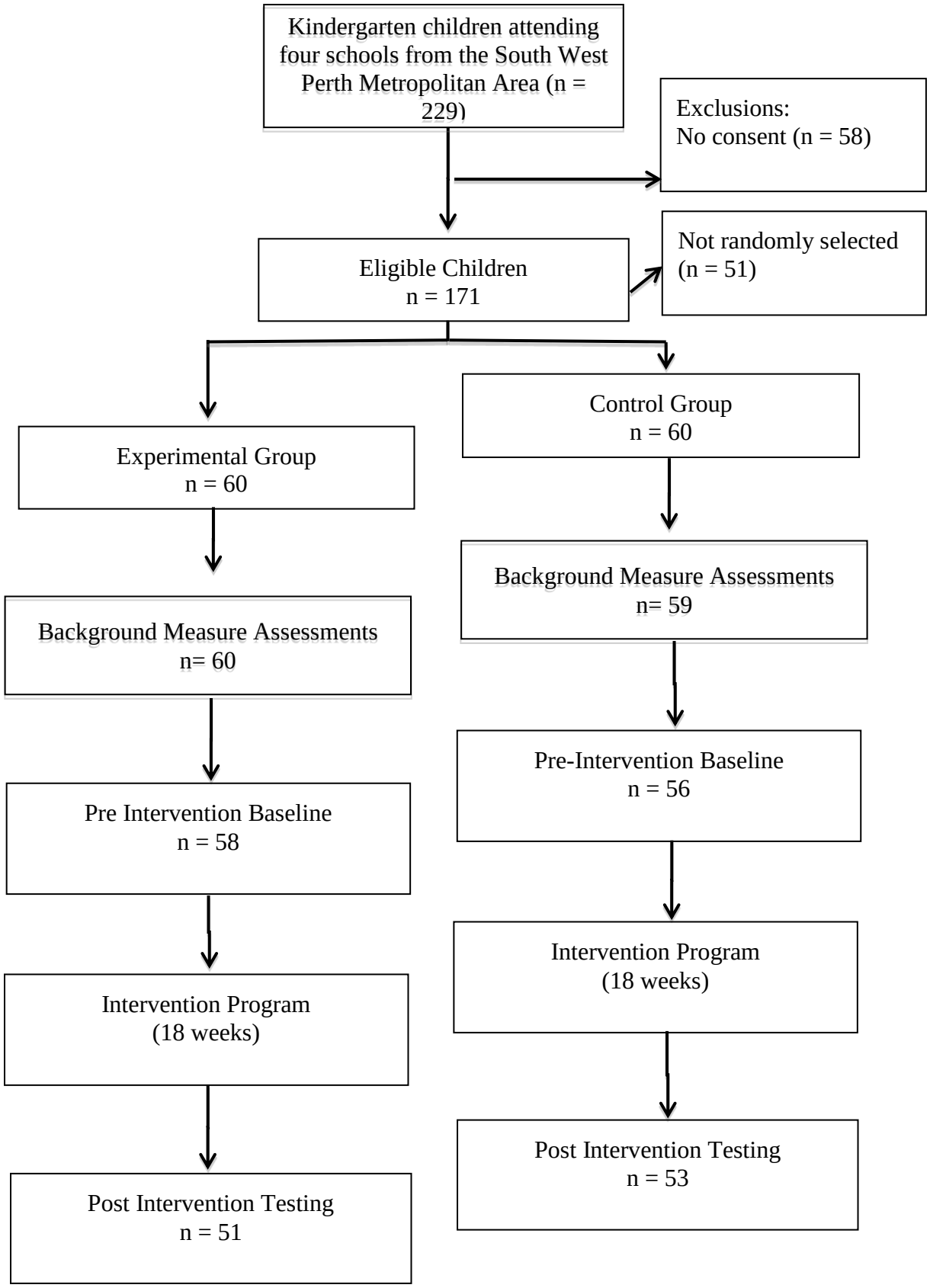
Appendix A: Cracking the Code Module Goals (2nd Edition)

Module One **Syllable Identification: How Many Claps** **Syllable Blending: Find the Star** **Onset-Rime Identification (Initial Sound): Initial Sound Spinner** **Onset-Rime Blending: Secret Picture**
Module Two **Syllable Blending: Sounds Like Bingo** **Syllable Segmentation: Cross the River** **Onset-Rime Identification (Initial Sound): Treasure Hunt** **Onset-Rime Blending: Find the Mouse**
Module Three **Syllable Blending: Syllable Fly Swat** **Syllable Segmentation: Lily Pad Leap Frog** **Onset-Rime Segmentation (Initial Sound): Pass the Parcel** **Onset-Rime (Rhyme Detection): Save a Bug**
Module Four **Onset-Rime Segmentation (Initial Sound): Phoneme Backpack** **Onset-Rime (Rhyme Detection): Piggy Banks** **Phoneme Final Sound Identification: Hopscotch** **Phoneme CVC Blending: Shopping Trolley**
Module Five **Phoneme Final Sound Segmentation: I Spy** **Phoneme CVC Blending: CVC Bingo** **Onset-Rime (Rhyme Generation): Rhyme Fishing** **CVC Identification: Say the Sounds**
Module Six **Phoneme CVC Segmentation: Treasure Hunt** **Phoneme Final Sound Segmentation: Bean Bag Toss** **Phoneme Medial Sound Identification: Board Game** **Phoneme CVC Blending: Make a Scene**

Module Seven **Onset-Rime (Rhyme Generation): Rhyme Generation Board Game** **Phoneme CVC Segmentation: Chicks and Snakes** **Phoneme Medial Sound Identification: Pass the Parcel** **Phoneme CCVC Blending: Caterpillar Crawl**
Module Eight **Phoneme Medial Sound Segmentation: Medial Sound Train** **Phoneme CVC Segmentation: Magician** **Phoneme CCVC Blending: Detective** **Phoneme CCVC Segmentation: Pet Shop**
Module Nine **Phoneme Medial Sound Segmentation: Feeding Bunyips** **Phoneme CCVC Segmentation: Very Hungry Caterpillar** **Phoneme CVCC Blending: Fishing** **Phoneme CVCC Segmentation: Bean Bag Toss**
Module Ten **Phoneme CVCC Blending: Magician** **Phoneme CVCC Segmentation: Picking Apples** **Phoneme Initial Sound Deletion (CVC): Alien Spaceship** **Phoneme Mixed Segmentation (CVC, CCVC, CVCC): Amusement Park**

Developed By; Chrissy Kelly, Daniella Cicerello & Heidi Crow, Fremantle Language Development Centre

Appendix B: Participant Flow



Appendix C: Cracking the Code Phonological Awareness Assessment

"Cracking the Code"

Phonological Awareness Assessment Tool

Notes for tester

Practice items: Present the practice item and give either confirmation of a correct answer **or** provide corrective feedback following an incorrect answer. The purpose of providing the feedback is to ensure that the child actually understands the instructions and to provide information about the child's responsiveness to teaching.

Discontinuation Rule: If the child scores zero on the first five test items within any subtest – discontinue that subtest and move to the next one (or move to the subtest specified by the relevant discontinuation rule).

Developed By: Chrissy Kelly & Daniella Cicerello

Cracking the Code

Phonological Awareness Assessment Tool

Student name: _____ **DOB:** _____
Assessor: _____
School: _____ **Year:** _____

Equipment required to administer test:

- Counters for Syllable Level Segmentation (x 6)
- Elkonin Boxes (stars) for Phoneme Level Segmentation
- Elkonin Boxes (3 & 4) to indicate target sound position

Syllable Level		
1.1 Blending Syllables ***Explanation:*** *"I am going to say some words. I am going to say them broken up into some parts, and I want you to put the parts back together to make the whole word. If I said ca-rrot, I could push those parts back together to make carrot"* ***Practice:*** *"What word am I saying now…, win-dow?* **What is this word?** a) Ba-lle-ri-na b) Po-ta-to c) Rec-tan-gle d) A-lli-ga-tor e) Re-fri-ge-ra-tor f) E – lec – tri – ci - ty g) Gla - sses h) Bro- cco -li i) Doc - tor j) Aus – tra – li - a	**Test One** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***	**Test Two** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***
1.2 Segmenting Syllables ***Explanation:*** *"I am going to say some words. I am going to break them up into some parts or syllables. So if I wanted to break up scissors, I would say sci – ssors"* ***(use 'star' boxes as a visual support)*** ***Practice:*** *"Can you show me the syllables/parts in letter?"* **Show me the syllables/parts in…….** a) Paper (2) b) Microwave (3) c) Rhinocerous (4) d) Box (1) e) Hippopotamus (5) f) Motorcycle (4) g) Teddy (2) h) Tyrannosaurus (5) i) Basketball (3) j) Push (1)	**Test One** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***	**Test Two** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***

<table>
<tr><td>Syllable Level Total</td><td>/ 20</td><td>/ 20</td></tr>
<tr><td>Comments/observations:</td><td></td><td></td></tr>
<tr><td>Onset-Rime Level</td><td></td><td></td></tr>
<tr><td>2.1 Rhyme Detection
Explanation: “We need to choose words which rhyme or sound the same at the end. So if I said the words cat, top and hat…. The two words which rhyme would be cat and hat, they both have ‘at’ at the end.”

Practice: “What rhymes with dog…. dog- red or dog-log?”

What rhymes with……
a) Pat: Sat or Frog
b) Fig: Hat or Rig
c) Fake: Dog or Lake
d) Fair: Deer or Care
e) Clown: Frown or Close
f) Fun: Fit or None
g) Coal: Foal or Log
h) Fed: Said or Fad
i) See: Me or Sheep
j) Dock: Knock or Deep</td><td>Test One
a) _____ f) _____
b) _____ g) _____
c) _____ h) _____
d) _____ i) _____
e) _____ j) _____
Score: / 10</td><td>Test Two
a) _____ f) _____
b) _____ g) _____
c) _____ h) _____
d) _____ i) _____
e) _____ j) _____
Score: / 10</td></tr>
<tr><td>2.2 Rhyme Generation
Explanation: “These words rhyme: will, bill, mill, sill, till. They rhyme; they sound the same on the end. Tell me lots of words that rhyme with these, they don’t have to be real words, they can be made up or silly.”
(Prompting for more is ok, aiming for 3 examples for each word)

Practice: “Think of some words that rhyme with fish?”

Think of some words that rhyme with……
a) Pat
b) Ban
c) Fin
d) Call
e) Hop
f) Bite
g) Fake
h) Land
i) Do
j) Bold</td><td>Test One
a) _____ f) _____
b) _____ g) _____
c) _____ h) _____
d) _____ i) _____
e) _____ j) _____
Score: / 10</td><td>Test Two
a) _____ f) _____
b) _____ g) _____
c) _____ h) _____
d) _____ i) _____
e) _____ j) _____
Score: / 10</td></tr>
<tr><td>2.3 Blending Onset and Rime (CVC)
Explanation: “I am going to say some words. I am going to say them broken up into some parts, and I want you to put the parts back together to make the whole word. If I said d –og, I could push those parts back together to make dog”

Practice: “What word am I saying now… s – un?”

What is this word?
a) M - ess
b) S - eed
f) Ch - in
g) B - ase</td><td>Test One
a) _____ f) _____
b) _____ g) _____
c) _____ h) _____
d) _____ i) _____
e) _____ j) _____</td><td>Test Two
a) _____ f) _____
b) _____ g) _____
c) _____ h) _____
d) _____ i) _____
e) _____ j) _____</td></tr>
</table>

c) F - ace d) H - ide f) Sh - ut h) G - um i) K - it j) T – alk	***Score: / 10***	***Score: / 10***
2.4 Naming Onset in CVC Words ***Explanation:*** *"I am going to say some words, and I want you to tell me the first sound you can hear in the word – so the sound that the word starts with. If I said pin, the first sound would be 'p'"* *(If child answers with letter name, prompt child by saying "that's the letter name, can you tell me the sound?")* ***(use elkonin (3) boxes to indicate target sound position)*** ***Practice: "****What is the first sound you can hear in* ***s****eat?"* ***What is the first sound you can hear in ……*** a) **P**eel b) **N**ote c) **D**im d) **W**et e) **Sh**eet f) **C**one g) **S**at h) **H**eart i) **T**op j) **G**ot If child scores 2 or less, omit subtest 2.5, 2.6 & 3.1 and proceed to subtest 3.2 **OR** If child scores 2 or less on **BOTH** subtests 2.3 (above) and 2.4 discontinue assessment	**Test One** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***	**Test Two** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***
2.5 Onset Deletion (CVC) ***Explanation:*** *"I'm going to say a word and I want you to take away the first sound and tell me what is left. So if I said 'sun' without the 's' it would turn into 'un'"* ***(use elkonin (3) boxes to indicate sound position)*** ***Practice: "****Say 'dig' without the 'd'."* **Say …….. without the ……** a) Choose (-ch) b) Mash (-m) c) Sell (-s) d) Fit (-f) e) Hole (-h) f) Bet (-b) g) Gaze (-g) h) Talk (-t) i) Peach (-p) j) Knock (-n) If child scores 2 or less, omit subtest 2.6 and proceed to subtest 3.1	**Test One** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***	**Test Two** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***
2.6 Onset Manipulation (CVC) ***Explanation:*** *"I'm going to say a word and I want you to change the first sound. So if I said 'bat' but changed the 'b' to a 'g' I would get 'gat'"* ***(use elkonin (3) boxes as a visual support)***	**Test One**	**Test Two**

Practice: ***"****Say 'pen' but change the 'p' to a 't."* **Say …….. but change the …. to a ….** a) Fog (m) f) Sell (d) b) Dish (p) g) Cash (n) c) Set (k) h) Fun (t) d) Dock (b) i) Dug (s) e) Pan (g) j) Map (f)	a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***	a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***
Onset-rime Total Score:	***/ 60***	***/ 60***
Comments/observations:		
Phoneme Level		
3.1 Naming Final Sound ***Explanation:*** *"I am going to say some words, and I want you to tell me the last sound you can hear in the word – so the sound that is at the end of the word. If I said 'bus', the last sound would be 's'"* ***(use elkonin (3) boxes to indicate target sound position)*** ***Practice:*** *"What is the last sound you can hear in 'late'?"* **What is the last sound you can hear in:** a) Tub f) Push b) Bark g) Leaf c) Mad h) Home d) Pat i) Soon e) Horse j) Buzz	**Test One** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***	**Test Two** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***
3.2 Phoneme Blending (CVC) ***Explanation: :*** *"I am going to say some words. I am going to say them broken up into sounds, and I want you to put the sounds back together to make the whole word. If I said t-o-p, I could push those parts back together to make top"* ***Practice:*** *"What word am I saying now… p-a-n?"* **What is this word:** a) B-ea-k f) Sh-o-p b) K-i-t g) M-a-ze c) D-u-g h) H-oo-p d) S-ea-t i) N-a-me e) Z-a-p j) T-i-p If child scores 2 or less, omit subtests 3.3 & 3.4, and proceed to 3.5	**Test One** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***	**Test Two** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***

3.3 Phoneme Blending (CCVC) ***Explanation:*** *"I am going to say some words. I am going to say them broken up into sounds, and I want you to put the sounds back together to make the whole word. If I said f-r-o-g, I could push those sounds back together to make frog"* ***Practice:*** *"What word am I saying now… f-l-a-g?"* **What is this word:** a) S-t-e-m b) S-n-ea-k c) S-p-ea-k d) S-l-i-de e) S-m-e-ll f) F-l-a-t g) P-l-ea-se h) B-l-o-ck i) G-l-u-m j) C-l-ea-n If child scores 2 or less, omit subtest 3.4, and proceed to 3.5	***Test One*** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***	***Test Two*** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***
3.4 Phoneme Blending (CVCC) ***Explanation:*** *"I am going to say some words. I am going to say them broken up into sounds, and I want you to put the sounds back together to make the whole word. If I said w-e-n-t, I could push those sounds back together to make went"* ***Practice:*** *"What word am I saying now… p-a-s-t?"* **What is this word:** a) M-a-s-t b) Gh-o-s-t c) R-a-m-p d) D-e-n-t e) H-u-n-t f) B-e-s-t g) Ch-i-l-d h) T-oa-s-t i) S-a-n-k j) P-a-s-t	***Test One*** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***	***Test Two*** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***
3.5 Segmenting CVC Words ***Explanation: "****Now we are going to stretch out some words. I want you to tell me all the sounds you can hear in the word. So all the sounds in the word 'Cat' are c-a-t."* ***(use elkonin (3) boxes as a visual support)*** ***Practice:*** *"Tell me the sounds you can hear in 'feet'"* **Tell me all the sounds you can hear in:** a) Bought b) Pit c) Cot d) Dart e) Team f) Sail g) Feed h) Wag i) Mop j) Him If child scores 2 or less, discontinue assessment.	***Test One*** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***	***Test Two*** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***
3.6 Naming Medial Sound ***Explanation:*** *"I am going to say some words, and I want you to tell me*		

what the middle sound you can hear in the word is – If I said 'fat', the sound in the middle would be 'a'" ***(use elkonin (3) boxes to indicate target sound position)*** ***Practice:*** *"What sound is in the middle of 'pet'?"* **What sound can you hear in the middle of:** a) Neat f) Boot b) Sill g) Top c) Head h) Make d) Dirt i) Fine e) Muck j) Cone	***Test One*** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***	***Test Two*** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***
3.7 Segmenting CCVC Words ***Explanation:*** *"Now we are going to stretch out some more words. I want you to tell me all the sounds you can hear in the word. So all the sounds in the word 'Sleep' are s-l-ee-p."* ***(use elkonin (4) boxes as a visual support)*** ***Practice: "****Tell me all the sounds you can hear in 'Clap'"* **Tell me all the sounds you can hear in:** a) Blame f) Span b) Gloom g) Float c) Snip h) Scan d) Skate i) Smoke e) Clam j) Plot If child scores 2 or less, discontinue assessment.	***Test One*** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***	***Test Two*** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***
3.8 Segmenting CVCC Words ***Explanation:*** *"Now we are going to stretch out some more words. I want you to tell me all the sounds you can hear in the word. So all the sounds in the word 'Desk' are d-e-s-k."* ***(use elkonin (4) boxes as a visual support)*** ***Practice:*** *"Tell me all the sounds you can hear in 'cost'"* **Tell me all the sounds you can hear in:** a) Sand f) Built b) Wasp g) Fold c) Dent h) Bank d) Film i) Help e) Gust j) Task If child scores 2 or less, discontinue assessment.	***Test One*** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***	***Test Two*** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***
3.9 Deleting Initial Sound (CCVC Words) ***Explanation:*** *"I'm going to say a word and I want you to take away the first sound and tell me what is left. So if I said 'Plan' without the 'p' it would turn into 'lan'"* ***(use elkonin (4) boxes to indicate sound position)***		

	Test One	Test Two
Practice: ***"****What is 'Plane' without the 'p'"* **Say……. without the ……...** a) Slop (-s) f) Snout (-s) b) Blaze (-b) g) Flute (-f) c) Cloud (-c) h) Smoke (-s) d) Space (-s) i) Scam (-s) e) Gloat (-g) j) Close (-c) If child scores 2 or less, discontinue assessment.	a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***	a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***
3.10 Manipulating Initial Sounds (CCVC Words) ***Explanation:*** *"I'm going to say a word and I want you to change the first sound. So if I said 'Greed' but changed the 'g' to a 't' I would get 'treed'"* ***(use elkonin (4) boxes as a visual support)*** ***Practice:*** *"Say 'plate' but change the 'p' to a 'k'"* **Say……. but change the ……. (initial sound) to an…….** a) Blink (f) f) Plait (b) b) Flop (c) g) Clash (p) c) Glad (s) h) Flap (p) d) Slam (b) i) Slug (f) e) Click (b) j) Plan (s) If child scores 2 or less, discontinue assessment.	***Test One*** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***	***Test Two*** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***
3.11 Manipulating Medial Sound (CVC Words) ***Explanation:*** *"I'm going to say a word and I want you to change the middle sound. So if I said 'Sat' but changed the 'a' to an 'u' I would get 'Sut'"* ***(use elkonin (3) boxes as a visual support)*** ***Practice:*** "Say 'Dog but change the 'o' to an 'e'" **Say……. but change the ……. (middle sound) to an…….** a) Pan (o) f) Gate (igh) b) Sack (e) g) Deep (oo) c) Tin (u) h) Tool (oa) d) Fun (ay) i) Foal (a) e) Kick (ee) j) Fight (e)	***Test One*** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***	***Test Two*** a) _____ f) _____ b) _____ g) _____ c) _____ h) _____ d) _____ i) _____ e) _____ j) _____ ***Score: / 10***
Phoneme Level Score	***/ 110***	***/ 110***
Comments/observations:		

'Cracking the Code' Phonological Awareness Assessment Tool *(Kindergarten & Pre-Primary)*		
Student Name: _____ **DOB: _____** **Assessor: _____** **School: _____**	***Date:***	***Date:***
Syllable Level	***/ 20***	***/ 20***
Onset-Rime Level	***/ 60***	***/ 60***
Phoneme Level	***/ 110***	***/ 110***
Total Phonological Awareness Score	***/ 190***	***/ 190***

Appendix D: Non Word Reading and Spelling Assessment

Non Word Reading and Spelling Assessment

Non Word Spelling

1. sol
2. wub
3. ruz
4. mog
5. hin
6. kep OR cep
7. yat
8. dev
9. tid
10. jaf

Non Word Reading

1. tid
2. ruz
3. wub
4. kep
5. sol
6. dev
7. yat
8. hin
9. mog
10. jaf

Developed by Chrissy Kelly – Fremantle Language Development Centre Outreach Service 2014

Non Word Spelling Score Form

Participant Code: _____ DOB: _____
Assessor: _____Date of Test: _____

1. _____ ☐ ☐ ☐

2. _____ ☐ ☐ ☐

3. _____ ☐ ☐ ☐

4. _____ ☐ ☐ ☐

5. _____ ☐ ☐ ☐

6. _____ ☐ ☐ ☐

7. _____ ☐ ☐ ☐

8. _____ ☐ ☐ ☐

9. _____ ☐ ☐ ☐

10. _____ ☐ ☐ ☐

Total: _____

Non Word Reading Score Form

Participant Code: _____ DOB: _____
Assessor: _____ Date of Test: _____

1. tid _____ ☐ ☐ ☐

2. ruz _____ ☐ ☐ ☐

3. wub _____ ☐ ☐ ☐

4. kep _____ ☐ ☐ ☐

5. sol _____ ☐ ☐ ☐

6. dev _____ ☐ ☐ ☐

7. yat _____ ☐ ☐ ☐

8. hin _____ ☐ ☐ ☐

9. mog _____ ☐ ☐ ☐

10. jaf _____ ☐ ☐ ☐

Total: _____

Non Word Reading Stimulus Cards

tid
ruz
wub
kep
sol
dev
yat
hin
mog
jaf

Appendix E: Teacher Questionnaires

Cracking the Code – Teacher Questionnaire

Teacher Name: _____

Phonological Awareness Component

Were any rotational group sessions missed? (Please provide details)

Did all sessions run for the correct amount of time (10 minutes per activity)? (Please provide details)

Who was responsible for running the groups (please include qualifications)?

Were these staff members consistent? (Please provide details)

Were all participating staff involved in modelling sessions provided by the speech pathologist? (Please provide details)

Did all participating staff attend the PD provided by the speech pathologist at the beginning of the year? Please provide specific numbers of attendees?

Alphabet Knowledge Component

Were any alphabet knowledge sessions missed? (Please provide details)

Did all sessions run for the correct amount of time (15 minutes per session)? (Please provide details)

Who was responsible for running these sessions (please include qualifications)?

Was this staff member consistent?

Was there any additional time spent on phonological awareness and alphabet knowledge skills?

If so, how much time per week and please provide a brief description of the activities?

Effectiveness of Small Group Intervention – Teacher Questionnaire

Teacher Name: _____

Words, Grammar & Fun

Were any rotational group sessions missed? (Please provide details)

Did all sessions run for the correct amount of time (10 minutes per activity)? (Please provide details)

Who was responsible for running the groups (please include qualifications)?

Were these staff members consistent? (Please provide details)

Were all participating staff involved in modelling sessions provided by speech pathologist? (Please provide details)

Did all participating staff attend the PD provided by the speech pathologist at the beginning of the year? Please provide specific numbers of attendees?

Phonological Awareness & Alphabet Knowledge Instruction

How much time per week was spent on phonological awareness activities?

Please provide a description of your PA program throughout the year?
Please include information on;

- Format of intervention i.e. whole class, small group, individual
- Type of phonological awareness skills focussed on i.e. syllable, onset-rime, phoneme

How much time per week was spent on alphabet knowledge activities?

Please provide a description of your alphabet knowledge program throughout the year?
Please include information on;

- Format of intervention i.e. whole class, small group, individual
- Order and speed of introduction

Appendix F : Cracking the Code Phonological Awareness Activity Example

Bingo!

Module Five
Level: Phoneme Level: Blending
Goal: To blend phonemes together to form CVC words.

Equipment Required: CVC Bingo Boards, Counters.

Instructions:

1. Explain to the children, that when we listen to words, we can break them up into 'sounds' E.g. The sounds 'c-a-t' make the word 'cat'.
2. Provide guided practice for the group E.g. What word am I saying..... 'd-o-g'... ..yes, that's right it's 'dog' What word am I saying... .. 'l-igh-t'... ..yes, that's right it's 'light'.
3. Tell the children you are going to play a 'Bingo Game' and you will tell them which pictures they can put a counter on.
4. Give each child a bingo board, tell the children that you will call out words, broken up into their sounds. They have to try and guess the word, and then if they have the right picture on their board, they can put their hand up.
5. The group leader will tell the group a word, segmented into its sounds.
6. The children are then required to blend the sounds together and check if the corresponding picture is on their bingo board. The first child to cover all their pictures is the winner.

How to make it easier:

- Say the segmented sounds closer together.
- Segment into onset and rime E.g. d-og.
- Model the correct answer E.g. d-a-t is 'hat'.

How to make it harder:

- Ask the child to do the segmenting.

Developed By; Chrissy Kelly, Daniella Cicerello & Heidi Crow, Fremantle Language Development Centre Outreach Service

Appendix G: Words, Grammar and Fun (Phase One) – Program Goals

Block	Semantics	Grammar
Block 1	**Goal: To comprehend and express LABELS from a range of categories.** Abracadabra': Children will be asked to help a magician place some items into his magic hat. They will need to listen carefully as the group leader asks them to find pictures from a range of categories, using their magic wand, in order to place them in the hat. When all the pictures have been placed in the hat, the children will need to label the pictures as they are pulled from the hat by the magician (group leader).	**Goal: To comprehend a range of VERBS and express them using PAST TENSE 'ed'.** 'Musical Spots': Children will play a version of 'musical statues'. Children will stand on a spot. The group leader will ask the children to demonstrate an action (ie. 'Everyone show me jumping'). When the group leader calls stop (or stops playing the maraca), children will need to move back to their spot as quickly as possible and identify the action they just completed e.g. 'I/We jumped'.
Block 2	**Goal: To correctly identify FUNCTION and LOCATION of objects** 'Functions Fishing': Each child will be required to 'fish' for a picture. Children will be given a brief description of the item and will then be required to identify the function and location. Following the correct identification, all children will then 'act out' the function.	**Goal: To correctly comprehend the PREPOSITIONAL concepts of UNDER, IN FRONT, BEHIND, ABOVE, BELOW, NEXT TO, BESIDE, BETWEEN, TOP, MIDDLE AND BOTTOM.** 'Animals on the Toy Shelf': Each child will be given an 'animal' and a 'ball'. A set of shelves will be placed in the middle of the group. The children will then be required to follow instructions containing various prepositional concepts.
Block 3	**Goal: To correctly LABEL items and describe ATTRIBUTES.** 'Detective': A child will choose a picture and then will be supported to provide a description of the picture to the rest of the group. Another child will then be required to use a magnifying glass to find the picture that matches that description. The children will then be asked to label the picture they have selected.	**Goal: To correctly use REGULAR and IRREGULAR PLURALS.** Memory': The group will play a game of memory, with a twist! Instead of matching exact pairs of cards, the children will be required to match one item, and a picture of many matching items (ie. I found one dog, and three dogs). The aim is for the children mark regular and irregular plurals.
Block 4	**Goal: To correctly comprehend the concepts of SAME and DIFFERENT, and expressively describe ATTRIBUTES.** 'Cross the Tightrope': Children will be asked to walk along a 'tightrope' to select a picture pair. The child will then be asked to describe the similarities and	**Goal: To correctly comprehend and use the personal pronouns 'HE' and 'SHE'.** 'Pass the Parcel': Children choose a picture pair (depicting a male and a female completing the same action) from the box. The child will be asked to identify what each person is doing in the picture using the sentence form 'He is

	differences using the comparison chart and description cues for support.	xxxing' OR 'She is xxxing'.
Block 5	**Goal: To SORT a range of items into their correct CATEGORY, and LABEL a range of CATEGORIES.** 'Treasure Hunt': Children will be asked to help some pirates who have lost their treasures. They will need to dig in the sand (rice box) for pictures and then give them to the corresponding pirate (ANIMALS, TRANSPORT, CLOTHING, FOOD and THINGS FROM YOUR HOUSE). Children will demonstrate sorting skills, and will need to label the category. As an increased step children will also be given the opportunity to sort the broad categories outlined above e.g. Food, into sub categories e.g. Fruit and Vegetables.	**Goal: To correctly use personal pronouns 'HE', 'SHE' & 'THEY' within the sentence structure: HE/SHE/THEY IS/ARE XXXING.** 'Board Game': Children will be supported to play a traditional board game. Children will take turns rolling the dice and moving their token. For each picture a child lands on, they must explain what is happening in the picture using the standard sentence structure 'THEY are XXXing' or 'HE/SHE is XXXing'.
Block 6	**Goal: To correctly comprehend and respond to WHO, WHAT and WHERE questions.** **'**Kangaroo Hops': Children listen a sentence and answer who, what and where questions as they hop 'like a kangaroo' to the next footprint.	**Goal: To correctly use personal pronouns 'HE', 'SHE' & 'THEY' within the sentence structure: HE/SHE/THEY WAS/WERE XXXING.** 'Star of the Show' will choose a verb picture from a bag/box. All children then act out the verb e.g jumping. The group leader will then ask the star of the show 'What did everyone do?' followed by 'What did XXX (individual group member) do?' The child will answer accordingly 'They/he/she was/were jumping'.

Note: 'Group Leader' refers to Teacher/EA/AIEO etc

Appendix H: Words, Grammar & Fun Activity Example

TITLE: Pass the Parcel!

Area of Language Targeted: GRAMMAR (Block 4)
Equipment Required: Pass the parcel box containing he/she picture pairs, counters, musical instrument or music CD (if available).
Goal/s: To correctly comprehend and use the personal pronouns 'HE' and 'SHE'.

Instructions:

1. Provide explicit teaching for the use of 'he' and 'she'. For example, 'When we talk about a boy or a man we say HE. Ben is happy. HE is smiling. When we talk about a girl or a woman we say SHE. Lucy is sad. SHE is crying'. Have a group discussion using the children in the group to provide examples.
2. Tell the children that they are going to play a game of pass the parcel. Explain to the children that they need to take one picture from the box when it is their turn.
3. Once the child has chosen a card, point to the pictures and say 'Tell me what the girl/boy is doing'
4. Encourage the child to use the format 'HE/SHE is XXXing' to respond (use the three counters to indicate the number of words the child is required to say).
5. Once the child has identified the correct sentence for each picture engage the entire group by asking 'Tell me what the girl is doing?/ Tell me what the boy is doing'. Children will respond using the standard sentence 'HE/SHE is XXXing'.
6. The children will be asked to pass the box around the group to ensure all group members get at least one turn. To make the game more engaging you may wish to play music in the background whilst children 'pass the parcel'. Children are required to stop when the music stops.

How to make it easier:

- Repeat the instruction.
- If the child is producing a one word answer, use the counters to indicate the number of words you want them to produce (e.g. He is running)
- Revise the use of HE/SHE e.g. 'Remember we use SHE for a girl and HE for a boy.
- Model correct answer e.g point to the boy and say 'Here is a boy. He is XXXing' or 'Here is a girl. She is XXXing'.

How to make it harder:

- Ask the child to produce two sentences e.g. 'He is jumping AND she is jumping'.

Developed By; C. Kelly, D. Cicerello, R. Bongiascia, H. Crow & K. Walmsley, Fremantle Language Development Centre Outreach Service.

Appendix I: Alphabet Knowledge Activity Example

Session Three

Automatic Recall and Fishing

Goal: For students to correctly name the letters "s, a, t, p, i, n" and identify their corresponding sounds.

Activity:

Phase One – Automatic Recall

- Present flash cards or Power Point slides of individual upper and lowercase letters for rapid recall.

Phase Two – Fishing Game

- As a whole class, the students sit around a pretend pond and fish for letters.
- Students to match the lowercase letters on the fish with the uppercase letters on the letter boards.
- Alternatively, students may be asked to match the uppercase letters (on the letter board) to the lowercase letters (on the fish).

Materials: Power Point slides / letter cards
Fish
Fishing rod
Letter boards

Session Four

Writing Letters (Lowercase)

Goal: For students to correctly write the lowercase letters "s, a, t, p, i, n"

Activity:

Small group activity

Present the students with the lowercase writing sheets

"Today we are going to do some writing. We are writing the letters "s, a, t, p, i, n".

Alternatively, you could point to the letters and ask *"what letter is this?"* or *"what sound does this letter make?"*

Materials: Laminated writing sheets
Whiteboard markers