

The effectiveness of a classroom based phonological awareness program for 4-5 year olds

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Abstract

Purpose: Numerous studies have reported a robust relationship between early phonological awareness (PA) and subsequent reading achievement (National Reading Panel, 2000), in addition to the critical role of the alphabetic principle in predicting and supporting later reading and spelling development (Burgess & Lonigan, 1998; McLachlan & Arrow, 2010). 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 students aged 3;8–5;4. CtC is a teacher-implemented program, designed to explicitly target PA skills and alphabet knowledge.

Method: A pre-test post-test group design was used to evaluate the effectiveness of the program. Four schools in metropolitan Western Australia were randomly assigned to either the control or experimental condition within a parallel groups design. The control group participated in an alternative program matched for duration and frequency, targeting semantics and grammar.

Result: The children in the experimental condition improved significantly more in PA, alphabet knowledge and non-word reading, and spelling after intervention than the control group.

Conclusion: These findings demonstrate that classroom-based, teacher-delivered PA and alphabet knowledge instruction can be effective for 3;8–5;4 year-olds.

Introduction

Reading difficulties are widespread in Australia. In 2016, 40,000 15 year-olds (1 in 7) failed to meet Organisation for Economic Co-operation and Development basic reading standards (ACER, 2016). 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, with the aim of facilitating later reading progress.

A substantial amount of research supports the need for the inclusion of phonological awareness (e.g. Carson, Gillon & Boustead, 2013; McIntosh, Crosbie, Holm, Dodd & Thomas, 2007), and alphabet knowledge teaching (e.g. Justice et al., 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. 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, 2005). There are limited studies which explore the effectiveness of such classroom based phonological awareness and alphabet knowledge interventions with the younger (3-5 years) age groups (e.g. Bailet, Repper, Murphy, Piasta & Zettler-Greeley, 2013; Carson et al., 2013; McIntosh et al., 2007; Tyler, Osterhouse, Wickham, Mcnutt & Shao, 2014). Further research is thus required to investigate the effectiveness of phonological awareness and alphabet knowledge teaching within an educational setting.

Phonological Awareness

Phonological awareness comprises a variety of skills including the ability to attend to, and make judgments about the sound structure of words (Schuele & Boudreau, 2008). It has

been argued that the development of phonological awareness occurs along a continuum rather than in discrete stages, with development of both linguistic skills (word, syllable, onset-rime, phoneme) and task skills (e.g. blending, deletion) occurring concurrently (Anthony, Lonigan, Driscoll, Phillips & Burgess, 2003). Syllable and onset-rime awareness is evident in many 3-4 year old children, with sensitivity to phonemes identified in 4-5 year olds (Lonigan, Burgess, Anthony & Barker, 1998).

Recent changes to the school starting age and modifications to the national curriculum in Australia have resulted in changing expectations for classroom practice. Expectations of earlier acquisition of reading and spelling (Australian Curriculum Assessment and Reporting Authority, 2012) means that explicit phonemic awareness instruction is now recommended for all children, highlighting the need for further investigation into the interventions at the lower age boundaries.

The significance of phonological awareness - The link to reading and spelling.

Evidence supports the relationship between phonological awareness, and early reading and spelling acquisition (Gillon, 2005; National Reading Panel, 2000). Share and Stanovich (1995) report underlying deficits in phonological awareness in a large proportion of children who experience reading difficulties, with many researchers also emphasising the negative influence of lower Socio-Economic-Status (SES) on phonological awareness abilities due to parental-education and income disadvantage, and reduced exposure to reading related activities (e.g. Lonigan et al., 1998; McDowell, Lonigan & Goldstein, 2007). Furthermore, children who experience phonological awareness difficulties in their early years often continue to fall behind their peers (Moore, Evans & Dowson, 2005).

While there is a considerable body of research into phonological awareness intervention and its effects on reading and spelling development, most has been laboratory based efficacy studies (e.g. Lonigan, Purpura, Wilson, Walker & Clancy-Menchetti, 2013), often conducted

with older age groups (5 years and above) (e.g. Ehri et al., 2001). While these studies provide evidence to support the effectiveness of phonological awareness under highly controlled conditions, it is critical to investigate whether such intervention is also successful under ‘real world’ conditions.

Phonological awareness intervention parameters. 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 et al., 2013; Tyler et al, 2014., 2001; Kruse, Spencer, Olszewski & Goldstein, 2015; McIntosh et al., 2007). Most relevant for the current study are the findings of effectiveness studies within classroom settings, and those which targeted the earlier age cohort of five years and under.

When reviewing these studies it is important to consider the parameters of intervention. Carson, Gillon and Boustead (2013) outline a framework for 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 of 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 those focussing on a range of phonological awareness levels (e.g. syllable, onset-rime and phoneme) classified as ‘broad’, and those focussed solely at the phoneme level, classified as ‘narrow’.

McIntosh et al. (2007) investigated the effectiveness of a speech-language pathologist developed, classroom teacher implemented program in the areas of language development and phonological awareness. This Australian study included 97 children aged 4;5 to 5;1. The phonological awareness component of the program targeted syllable and onset-rime level,

lasted for 10 weeks, and included two hours of instructional time per week. Immediately following this short, high intensity, broad program, significant phonological awareness gains were made by the treatment group compared with the controls, who were exposed only to their regular curriculum. 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 target phonemic awareness, that is, awareness of individual phonemes, as part of its instruction. This finding is particularly important given the research (e.g. Carson et al., 2013), which links phonemic awareness to more robust reading and spelling outcomes.

Other research has investigated the inclusion of phonemic awareness within a broad program. Tyler and colleagues (2014) examined the effectiveness of a teacher-delivered phonological awareness program over a 10 week period. The study included 24 children aged between 3;10 and 4;11, classified as being 'at risk' due to low socio-economic status or speech-language impairments. Instruction was delivered four times per week, 20 minutes per session (low intensity) and focussed on letter-sound awareness, initial sound awareness, and blending and segmentation of compound words, onset-rime and phonemes. A cross-over, delayed treatment approach design was used to investigate the effects of the intervention. Participants in both groups showed significant improvement in phoneme blending when compared to the group receiving their regular curriculum. However, for the first treatment group, these gains were not sustained four months post intervention. The gains seen in this study, particularly with regards to phoneme blending with limited exposure, suggest capacity for substantial change. It is possible that continued instruction over a longer period to increase exposure time could lead to further and more sustained gains.

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 participants aged 5;0-5;2. Thirty-four children received ten weeks of phonological awareness intervention (four, 30-minute sessions per week) focussing on rhyme oddity and phoneme level tasks. The remaining participants continued with their usual reading curriculum which included phonics instruction, but did not explicitly target phonological awareness. Results indicated significant and sustained reading and spelling gains over a six-month period when compared with participant controls. The promising results of this study suggest that high intensity 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 suggest that instruction lasting for a short period, of low intensity, 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 the activities, can lead to improved phonological awareness, reading, and spelling in younger children.

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, (2008) 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. It has also 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; Zill & Resnick, 2006 in Phillips et al., 2008). It is likely that these findings can be applied to the Australian context.

Parameters of classroom instruction. The evidence suggests that phonological awareness development is best achieved through one-to-one or small group instruction (Lonigan, Schatschneider & Westberg, 2008). In addition, Phillips and colleagues (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.

Alphabet Knowledge

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, 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, other children, including those at risk for later reading difficulties and those from disadvantaged backgrounds, often do not (National Research Council, 1998), highlighting the need for explicit teaching.

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 (Gillon, 2005). There is increasing 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), and reported that letter knowledge measures collected at 3;9 were 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 (Piasta & Wagner, 2010). The results of Piasta and Wagner's (2010) meta-analysis are inconclusive in demonstrating a causal relationship between alphabet knowledge (name and/or sound) and reading and spelling outcomes. However, interventions within many of the included studies did not specifically focus on providing letter name and/or sound instruction, but rather included this as a minor or incidental section of a larger literacy program, making interpretation of the findings somewhat difficult. It is also possible 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.

Cracking the Code - 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 (CtC) program (Fremantle LDC Outreach Service, 2013) was developed. The program was designed and written by speech-language 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. Within the framework described by Carson, Gillon and Boustead (2013), CtC can be described as a *short duration, low intensity*

program which integrates instruction across a *broad* range of phonological awareness skills with an emphasis on phonemic awareness. While much of the research has highlighted the effectiveness of high intensity instruction (e.g. Carson et al., 2013), low intensity instruction was selected due to demanding school schedules and limited classroom instructional time.

The purpose of the current study was to examine the effectiveness of CtC in improving phonological awareness skills and alphabet knowledge (name and sound) in children aged 3;8-5;4. In addition, this study aimed to examine the effectiveness of CtC in improving emerging reading and spelling abilities in participating children. The study addressed the following hypotheses;

1. Children who participate in Cracking the Code will demonstrate significantly higher phonological awareness skills than children who receive their usual curriculum.
2. Children who participate in Cracking the Code will demonstrate significantly higher alphabet knowledge skills than children who receive their usual curriculum.
3. Children who participate in Cracking the Code will demonstrate significantly higher non-word reading and non-word spelling skills than children who receive their usual curriculum.

Method

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. Kindergarten in Western Australia is the first year of schooling. Children must turn 4 years of age by the 30th June in the year they enrol. They attend 2.5 - 3 days per week. We drew participants from four mainstream schools within the Perth Metropolitan area. Schools in the area all have formalised classes from kindergarten to year six, which are teacher-run and under the management of the principal. We matched schools involved in the study on the following characteristics: (1) geographical location and

(2) relative socioeconomic advantage or disadvantage. Following ethics approval, we invited principals of all 40 Department of Education primary schools within the area to participate in the study. From the ten schools that confirmed interest four were deemed ineligible due to insufficient student numbers, differing school structures, current speech pathology programs already in place or previous access to the CtC program. From the remaining 6 schools, we selected four to take part based on similar indices of relative socio-economic advantage and disadvantage (IRSAD) to limit any effect of SES. IRSAD scores summarise the economic and social conditions of people and households within a geographical area. Schools selected received decile scores (a ranking score established by splitting up data into ten equal subsections) of nine and ten, indicating that selected schools were classified as having a lack of disadvantage and greater advantage in general. Three out of the four schools had two kindergarten classes each, with the remaining school having four kindergarten classes. 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. Only those children who had parental/guardian consent were eligible to have their data included in the research project, and took part in the full assessment protocol. Consent forms were returned for 171 students, however due to time and financial constraints, 120 students overall, comprising 30 from each school, were randomly selected for inclusion in the study.

Procedure

A pre-test/post-test 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 (see Figure 1).

Insert Figure 1 about here

We used the Cracking the Code Program (CtC; FLDC Outreach Service, 2014) with the experimental group during the intervention phase of this project. CtC has 10 sequential modules that increase in complexity. 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, and phoneme). An outline of the modules and an example task instruction card can be seen in the online supplementary materials. 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. CtC first focuses on explicitly teaching PA and alphabet knowledge separately, and consolidation of these skills, before combining them within some of the later PA modules, in order to represent sounds heard with written symbols, thus explicitly teaching the alphabetic principle. This allows the PA tasks to initially focus purely on sound-based skills without the aid of letter knowledge so as to not confuse sound and letter-based skills.

We used the Words, Grammar, and Fun program (WGF; FLDC Outreach Service, 2014) with the control group. WGF has six sequential blocks that increase in complexity. Each block contains one grammar and one semantics activity, and each activity also contains a detailed task instruction card.

Program implementation.

Intervention group. Based on similar performance on the phonological awareness and alphabet knowledge initial assessment measures, 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). In accordance with the CTC protocol, children were like-ability grouped based on the premise that phonological awareness development occurs along a continuum. Each group was then allocated to a starting module based on phonological awareness assessment scores.

Within each 40 minute, biweekly session, three trained education staff members (university-trained teachers and teaching assistants) were responsible for delivering the four phonological awareness activities (within the relevant module), to their designated student group. Each phonological awareness module was completed over three weeks, so each group completed six out of the 10 modules in total. The dedicated alphabet knowledge activities were delivered twice weekly, separate to the phonological awareness activities. Some alphabet knowledge activities were implemented with the whole class, and others in small groups; this was consistent across all classes and each was 15 minutes in duration. Sessions focussed on receptive and expressive knowledge of letter names and sounds, and written formation of letters.

Control group. Following collection of initial assessment data, participants from each class were placed into one of three ‘mixed ability groups’. Adhering to the WGF protocol, mixed ability groups were used as the WGF intervention sequence was not dependent on prior exposure to other content. All groups commenced with the first block of activities within the WGF program, and all children completed the same activities in the same order.

Assessment Phases and Measures

Each student was tested prior to the intervention phase and after the conclusion of the intervention (see Figure 1). Speech-language pathologists, including the primary researcher, administered the CELF-P2 and ERB prior to the intervention phase. All remaining assessments were administered both pre- and post-intervention by trained research assistants (speech-language pathologists) who were blind to research group allocation.

Clinical Evaluation of Language Fundamentals – P2 (CELF –P2; Wiig, Secord & Semel, 2006). The Core Language Subtests from the CELF-P2: sentence structure, word structure and expressive vocabulary (Wiig, Secord & Semel, 2006), were individually

administered to all participating children in order to provide a standardised measure of overall language ability.

Early Repetition Battery (ERB; 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.

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 (aged 3;6 to 7;6). The assessment was developed for use with the CtC program (Kelly, 2016) and is currently non-standardised. 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 the online supplementary materials. While all children were assessed using the CTCPAA, the number of completed subtests varied according to performance-based discontinuation rules.

Alphabet Knowledge Assessment (FLDC Outreach Service, 2013). 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 randomised then presented in the same order to all children. All lower case letters were presented, followed by all upper case letters.

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. All participants completed both subtests. Within the first subtest, children attempt to

spell each of the ten non-words from dictation. For each non-word, one point per correct/appropriate grapheme was awarded, along with an additional point if the spelling was correct in its entirety. In the second subtest, children attempt to read each of the ten non-words from a standardised stimulus sheet. For each non-word, one point was awarded for each correctly identified phoneme-grapheme correspondence, with an additional point for reading the whole word. We presented words in lowercase New South Wales Foundation font. Within both subtests, words were presented in a pre-selected randomised order, this pre-selected order differed between subtests.

Treatment fidelity

To facilitate treatment fidelity, clear guidelines for dosage and implementation, as well as comprehensive training and modelling support, were provided. All staff involved in program implementation were either university-trained teachers or teaching assistants (with various levels of qualifications). We used the CtC and WGF instruction cards in training and throughout the teaching program in order to facilitate adherence to the intervention protocol. To further facilitate adherence to protocol, the primary researcher visited each classroom every three weeks to model lessons, give feedback to teachers, and answer any questions. Records of activity implementation (completed activities from each module and frequency of implementation) were also kept.

Result

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. 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 the expectation maximisation approach (Tabachnick & Fidell, 2013). This was carried out after finding that the data was

Missing at Random, following confirmation of non-significance of the separate-variance t tests conducted on the measured variables, after Little's Missing Completely at Random test was found to be statistically significant, $\chi^2(13) = 28.50, p = .008$. None of the statistical assumptions were violated prior to analysis. The standardised score control group means were CELF P2 101.27 (SD 14.95), ERB 106.37 (SD 19.83); and the experimental group means were CELF P2 98.9 (SD 15.87); ERB 108 (SD 18.52). 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, $d = .09$.

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 (total aggregate score) accounted for by the predictors within the model. As student-level predictors (level 1) were nested within IRSAD categories (level 2), multilevel modelling was used to determine the effectiveness of CtC in improving phonological awareness, alphabet knowledge, non-word reading and non-word spelling in kindergarten students. The influence of socio-economic status on the participants' enrolled schools, represented by the IRSAD measure, was treated as a random factor via randomly-varying intercepts in the models analysed. IRSAD was therefore treated as a nesting variable, that is, children within the same IRSAD band were considered to be more similar at onset in terms of their individual-level (e.g., PA) scores, in comparison to those in the other IRSAD band due to SES influences. The resultant differences in model intercepts on the basis of IRSAD were therefore a means of accounting for this source of participant variance, thereby enhancing estimates of the effects of individual-level differences (e.g., participation in CtC and its influence on PA) via this implementation of statistical control. The individual-level predictors (i.e., participation in CtC, pre-test PA scores (total aggregate score), short-term memory scores, and oral language scores) were then sequentially added to the model in the

described order, such that an assessment for the statistical significance of each added model parameter could be made at each step. Furthermore, this allowed for the calculation of the amount of variance each predictor added to the 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). That is, model fit $p < .01$ was considered statistically significant, instead of the typical $p < .05$ for statistical significance to be demonstrated. Pre and post-test results can be seen in Table I.

Scores for phonological awareness, alphabet knowledge, non-word reading and non-word spelling all increased over the treatment period for both groups. The experimental group showed greater gains than the control group, on average, from pre-test to post-test.

Descriptive scores can be seen in tables I and II.

Insert Table I and II about here

Intervention and Phonological Awareness

Prior to interpreting the results of the hierarchical model, several assumptions were evaluated. Univariate outliers were determined based on inspection of boxplots, with cases beyond the 95% whiskers in the plot earmarked as extreme cases. Univariate outliers were removed ($n = 5$) following identification in this regard, while multivariate outliers were not deemed to be of concern. The assumptions of normality, linearity and homoscedasticity of residuals were met. Finally, tolerances for all predictors in the final model indicated that multicollinearity was not problematic.

Within the null (no predictor) model, IRSAD was shown to significantly predict post-intervention phonological awareness scores, $F(1, 2) = 90.34$, $p = .011$. Calculation of the intra-class correlation coefficient (ICC) indicated that 6.88% of variance was accounted for

by IRSAD, suggesting that the random effects of socioeconomic advantage or disadvantage on PA scores was a notable, albeit small, influence on this outcome.

We then sequentially tested each individual-level predictor of PA, while accounting for the nested effect of IRSAD on students' scores, in order to determine the unique variance associated with each individual-level predictor of PA. We calculated unique variance per predictor based on the change in model information (specifically the -2 Log Likelihood coefficient) between sequential model variations (Heck, Thomas, & Tabata, 2014). Table III summarises our findings for the PA model with all predictors entered. Pre-test PA scores, short-term memory, and involvement in the CtC program were all significant and positive predictors of post-test PA ($p < .01$). Oral language score, while a positive predictor of post-test PA, was not statistically significant ($p > .01$) per the conservative alpha value against which it was judged. The predictor-variable-inclusive model's revised estimate of the ICC attributable to IRSAD variations in model intercepts suggested marginal variance in phonological awareness was accounted for by this random factor ($ICC = .027$, or 2.7%).

Insert Table III about here

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

Intervention and Alphabet Knowledge

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.

Within the null model, IRSAD was shown to significantly predict post alphabet knowledge scores, $F(1, 2) = 97.33, p = .010$. The intra-class correlation coefficient (ICC) showed that 2.96% of variance was accounted for by IRSAD. Table III summarises our findings for the prediction of alphabet knowledge the individual-level predictors. Involvement in the CtC program and pre-test alphabet knowledge scores were significant predictors of post-test alphabet knowledge scores. Short-term memory and oral language ability, however, were not significant contributors to this outcome. The predictor-variable-inclusive model's revised estimate of ICC demonstrated that IRSAD variations accounted for a notable proportion of variance in Alphabet Knowledge ($ICC = 0.131$, or 13.1%).

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

Intervention and Non-Word Reading

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.

Within the null model of the hierarchical analysis, IRSAD was not shown to significantly predict post non-word reading scores, $F(1, 2) = 20.05, p = .046$ against the more-conservative alpha of $\alpha = .01$ (Field, 2013). The intra-class correlation coefficient (ICC) showed 10.89% of variance was accounted for by the random effect of IRSAD on non-word reading scores for participants, despite the lack of statistical significance estimated for this finding. Non-word reading (NWR) scores were significantly predicted by involvement in CtC, pre-test NWR scores, and short-term memory scores. Oral language scores did not

contribute significant variance ($p > .01$) to the model when evaluated against the conservative family-wise alpha. The estimate of IRSAD-based random variance in NWR scores following the inclusion of predictors suggested sizable variation attributable to this clustering factor ($ICC = 0.229$, or 22.9%).

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

Intervention and Non-Word Spelling

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, IRSAD was not shown to significantly demonstrate random effects on participant post-test non-word spelling (NWS) 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 IRSAD differences. As demonstrated in Table III, involvement in the CtC program, participant pre-test NWS scores, and short-term memory scores of the participants were all significant predictors of post-test NWS scores. Oral language, consistent with the findings of the previous analyses, was not a significant predictor ($p > .01$) of post-test NWS scores when evaluated against the conservative alpha employed. The revised estimate of IRSAD-based random variance in participant NWS scores suggested minor yet notable variance associated with this clustering factor ($ICC = 0.075$, or 7.5%).

This finding also supports the third hypothesis that participation in the CtC program would lead to significant improvement in post-intervention non-word spelling scores.

Discussion

The purpose of this study was to evaluate the effectiveness of a classroom delivered phonological awareness and alphabet knowledge teaching program for children aged 3;8 -5;4. The program is of *short duration, 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. The results supported our 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.

Cracking the Code and Phonological Awareness

The first hypothesis proposed that Cracking the Code (CtC) would improve the phonological awareness skills of students aged between 3;8 -5;4. Participants in the experimental group made significantly more gains in phonological awareness than the control group by the end of the intervention period. This finding supports the conclusions of the National Reading Panel's meta-analysis (2000) that phonological awareness outcomes can be improved in response to phonological awareness instruction, indicating that these skills can be successfully taught with high quality intervention.

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. The post intervention mean phonological awareness score for the experimental group was 80/190. The mastery of phonological awareness skills reflected by this score 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 (SCSA, 2015).

The findings of the current study suggest that children aged 3;8 -5;4 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. This is consistent with Lonigan and colleagues (1998) who demonstrated syllable and onset-rime awareness in many 3-4 year old children, and sensitivity to phonemes in 4-5 year olds. The findings also provide support to the argument that explicit teaching yields earlier phonological awareness (onset-rime and phoneme level) skills (e.g. Ehri et al., 2001). The evidence to support phonological awareness skills being taught at a young age is particularly important, as children who present with deficits in phonological awareness in their early years often have persistent difficulties, especially without the provision of appropriate and explicit intervention (Moore et al., 2005).

The findings reported here also add to the small research base supporting the effectiveness of small group phonological awareness instruction in a classroom setting. This model of service delivery differs from 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, 2005). A pull-out model is less feasible in schools as it is generally more expensive with regards to both time and resources and typically services only a small number of students. The current findings indicate that the teaching of phonological awareness in classrooms by teachers to a wider range of students can be effective.

With regards to duration and intensity of effective phonological awareness instruction, the results are consistent with those reported by Tyler et al. (2014) and Justice et al. (2010), 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) can be effective in producing immediate gains. Although a narrow focus on phoneme level skills 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, CtC focused on earlier developing skills (syllable and onset-rime) in addition to phoneme awareness. Close inspection of the data (seen in Table II) illustrates that while gains were made at all levels, gains at the phoneme level were the most noteworthy difference between control and experimental groups. This suggests 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 et al., 2013) specifically linking phonemic awareness, in particular blending and segmenting of phonemes, to improved reading and spelling outcomes.

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. 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, following participation in CtC, the children are performing at the level consistent with or above the curriculum guidelines.

Gains seen in the experimental group support the explicit teaching of the alphabet within a literacy program, findings which are consistent with other research (Ehri & Roberts,

2006; 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, 2006; Gillon, 2005).

Cracking the Code and Non-Word Reading and Spelling

The third hypothesis 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, in spite of no direct instruction in word reading and spelling. These findings are consistent with the National Reading Panel's (2000) meta-analysis which reported that phonological awareness instruction improved phonological awareness and reading and spelling skills. However, the results are not consistent with 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 the absence of focussed alphabet knowledge instruction in most studies in the meta-analysis, the provision of phonological awareness instruction or an alternative form of alphabet instruction to the control groups in the meta-analysis studies, and the lack of focus on the contextual use of alphabet knowledge within whole word reading and spelling tasks. In contrast, CtC provided 540 minutes of focussed alphabet knowledge instruction time, and in later stages of the phonological awareness component of the program, provided instruction which included a focus on combining phonological awareness with alphabet knowledge in order to represent sounds heard with written symbols.

Limitations and Future Directions

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 regards to treatment fidelity. These included factors related to consistency of implementation by education staff, knowledge and education levels of 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 data related to staff qualifications and years of experience, 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 instructional time used in the experimental and control conditions.

While no children were excluded from the study, meaning that those ‘at-risk’ were included, no specific individual analyses were conducted on this cohort. A future study would therefore explicitly identify these participants to examine their responsiveness to intervention.

Given the potential influence of SES reported in the literature, the current study selected schools with decile IRSAD scores of nine and ten with the purpose of controlling for these differences. However, in order to statistically control for any potential differences, IRSAD

was included as a level 2 variable in the model. The results of the analysis showed that IRSAD was a significant predictor of post phonological awareness and alphabet knowledge scores. Thus, this highlights the need for future studies to statistically control for SES even within a narrow IRSAD band to preclude spurious findings.

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.

Conclusion

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 phonological awareness and alphabet knowledge as well as improved non-word spelling and reading. The program can be effectively delivered by education staff following training, supporting high quality classroom based instruction. The findings of this study 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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