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Classroom Implications of Recent Research into Literacy Development: From Predictors to Assessment

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Author Note

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Abstract

We outline how research into predictors of literacy underpins the development of increasingly accurate and informative assessments. We report three studies that emphasise the crucial role of speech and auditory skills on literacy development throughout primary and secondary school. Our first study addresses the effects of early childhood middle ear infections, the potential consequences for speech processing difficulties, and the impact on early literacy development. Our second study outlines how speech and auditory skills are crucially related to early literacy in normally developing readers, whereas other skills such as motor, memory and IQ are only indirectly related. Our third study outlines the on-going impact of phonological awareness on reading and wider academic achievement in secondary school pupils. Finally, we outline how teachers can use the current research to inform them about which assessments to conduct, and how to interpret the results.

Classroom Implications of Recent Research into Literacy Development: From Predictors to Assessment

Despite the wealth of research on predictors of literacy, we still have not developed clear and consistent methods for assessing literacy within the classroom. Since there is no single test available for assessing all aspects of literacy development, teachers concerned about pupils' reading difficulties require a thorough understanding of current theory in order to select suitable assessments and interpret the findings. A common theme of the research we describe is the importance of speech and auditory skills for literacy development, in particular the development of phonological awareness. Thus, the majority of literacy assessments available focus on the non-lexical (grapheme-phoneme) route to reading. We address four main issues. Firstly, we address one of the most common causes of early speech processing difficulties: middle ear infections in early childhood. Teachers are often unaware of the medical history of their pupils, and are unlikely to correctly identify children with a history of middle ear infection. We explain how these can affect children's speech processing and outline how teachers may be able to reduce the impact on children's literacy development. Secondly, we describe research into early predictors of normal literacy development. This research highlights the importance of speech and auditory skills and indicates that other skills, such as motor skills, IQ and memory, correlate with the crucial predictors of literacy but do not appear to have an independent causal influence on early success in learning to read. In order to accurately predict a child's literacy development, it is important to be able to distinguish between the skills that are directly involved in literacy development, and those skills that correlate with the crucial factors. Thirdly, we describe the long term impact of speech and auditory skills, specifically phonological awareness. We discuss how children with poor phonological skills can be identified even in secondary school classrooms. Phonological difficulties can continue to cause reading problems for older children and this has a knock-on effect on other areas of academic performance. Finally, we discuss how teachers can use the current research to inform them about which assessments to conduct, and how to interpret the results. Ultimately, we aim to demonstrate how current research can lead to improvements in literacy assessments and enable teachers to assess children's learning requirements accurately within the classroom. We address each of these four issues in the following sections, ending each section by outlining the implications of the research described for classroom practice. Two of the three studies described are summarised only briefly as they are reported more fully elsewhere.

The Impact of Early Middle Ear Infections on Literacy Development[1]

Background

Otitis media (OM) or middle ear infection is a common childhood illness and is most frequent during the first 3 years of life when speech and language skills are (or should be) developing at a fast rate. Episodes of OM typically result in a hearing loss of between 16-40 db, and this degree of hearing loss can impair speech perception. Several studies have looked at whether there are long-term phonological and/ or reading and language difficulties found in children with a history of OM. Many of these studies have compared the language and literacy skills of children with and without a history of recurrent OM. The results have been equivocal, some studies have found no significant effects, or else only early effects (e.g., Fischler et al., 1985; Roberts, Burchinal, & Zeisel, 2002; Teele et al., 1984), while others have found substantial differences between groups

[1] The results reported are from an ongoing project (Masterson & Grounds, in preparation)

(e.g., Finitzo, Gunnarson, & Clark, 1990; Friel-Patti & Finitzo, 1990; Gravel & Wallace, 1995; Menyuk, 1986; Winskel, 2006). Given the current lack of agreement in findings in this area, and the frequent reports of clinicians that many children with reading difficulties have histories of chronic otitis media, it seemed timely to conduct a study that took into account age of onset and severity of the illness.

Aims

Considering the vast changes in language which occur, particularly in the first three years of life, the age at which OM episodes are first experienced, their severity, and the number of years over which infections extend are all likely to be important determinants of whether or not long term effects on literacy development are observed.

The present study involved children with positive histories of OM (OM+) and control children (OM-), recruited via parental questionnaire from primary schools, who were tested on a range of literacy measures. Age of onset of OM was used to divide the OM+ group into early and late subgroups, since it was expected that the most serious consequences of episodes of mild to moderate intermittent hearing loss were likely to be found in children with earlier onset.

Methodology

Participants

Children aged 9 to 10 years with a positive OM history, involving repeated episodes persisting after three years of age, were recruited from primary schools in Essex, UK. A comparison group of 20 typically developing children was also recruited, from the same classrooms as the children with positive histories of OM. A parent/carer questionnaire was used in selecting the children for the study. This included questions relating to whether or not children had experienced episodes of OM, and, in the case of OM+ histories, the age of onset of OM, the severity and duration of episodes, and medical intervention.

Parent/carer and participant consent was obtained prior to children being included in the study. Of the children recruited, those with OM+ histories were divided into two onset age groups: 0-24 months (OM early, OME, N = 24) and 25+ months (OM late, OML, N = 20). The three groups did not differ in age or in proportion of males to females. Children with specific language impairment were excluded from the study, as were those with global learning or sensory difficulties and known social or emotional problems.

Materials and Procedure

A range of reading and reading-related assessments were administered to the children since, as well as comparing reading skill in OM+ and OM- children, the study aimed to specify which (if any) literacy sub-processes are vulnerable according to the age of onset of OM. Testers were blind to the group membership of children they assessed. Among the assessments were a standardised reading test (the Weschler Objective Reading Dimensions, WORD, Rust, Golombrok & Trickey, 1992) and spoonerisms, alliteration, and rapid naming subtests from the Phonological Assessment Battery (PhAB, Frederickson, Frith & Reason, 1997). For the latter, a single phonological awareness measure, using z scores, was derived for each child and used in the analyses of the results.

Results

There were significant group differences in reading test scores, and in the combined phonological awareness scores (full results will be reported in Masterson & Grounds, in preparation). In all cases the OME group demonstrated worse performance than the OM- and OML groups, who did not differ. However, it was noted that there were large standard deviations in the OME group. Inspection of the data indicated that poor reading and phonological awareness scores were apparent for the OME children with episodes persisting into the early school years (i.e., age 6+). Figure 1 gives the results for the OM- group and the OME group divided into children with OM that persisted after the age of six (N=14) and those with cessation of OM before six years (N=10)[2]. It can be seen that significant difficulties in the reading and phonological abilities assessments were present in the 6+ OME children.

Discussion

Late onset OM children did not differ in reading and phonological abilities overall from typically developing control children. Early onset OM children differed from typically developing and late onset OM children. Children most likely to show poor performance were those who had early onset of OM episodes that persisted into the early school years. This finding may help to explain the disagreement in previous literature; only some children with early OM are likely to have later literacy difficulties.

Implications for the Classroom

Recent neuroanatomical work by Xu, Kotak & Sanes (2007) suggests how hearing loss associated with OM may affect language and literacy development. Hearing loss comparable to that suffered by children with chronic OM increases thalamocortical

[2] The z-scores for the phonological awareness tasks are based on raw error scores and naming speed, so that positive results are indicative of poor performance.

synaptic depression, leading to tiny gaps in responses to the incoming signal. This means that listening to speech will be more effortful than for typically developing children, and particular difficulties will be experienced in noisy backgrounds (when the signal is weak we need to sample more often for accurate discrimination). The situation is analogous to being put in a foreign language class that is too advanced for us – we eventually give up trying to listen.

The implications of the present findings are that we need to be aware that hearing levels in children with a history of persistent OM will be inconsistent and they may experience difficulty with aspects of literacy development (and other language skills) as a result. Helpful interventions for such children may include steps such as aiming to keep background noise levels in the classroom low, making sure they sit at the front of the class and have a clear line of sight of the teacher for instructional activities, attracting their attention back to the task at intervals when they "wander off". In addition, monitoring for signs of lack of progress in reading and reading-related skills in children with chronic OM is indicated.

In summary, we have highlighted the crucial role of early speech processing deficits in causing reading difficulties. In this small-scale study we found that children who experienced chronic otitis media that persisted into the early years of school, a time that coincides with intensive literacy instruction, demonstrated deficits in phonological awareness and reading skill in comparison to typically developing children. In the next section, we examine the role of speech processing skills on reading development across the entire ability range. In particular, we will investigate more closely the impact of speech and auditory skills on early literacy development, in comparison with other key cognitive, sensory and motor skills.

Early Predictors of Literacy Development[3]

Background and Aims

Research on early literacy development has emphasised the importance of oral language in predicting phonological awareness and reading development (e.g. Carroll, Snowling, Hulme & Stevenson, 2003; Muter, Hulme, Snowling & Stevenson, 2004). In fact, oral language deficits, in particular phonological deficits, have also been highlighted as a crucial cause of early reading difficulties (e.g. Snowling, 2001). However, studies with older children and adults have found that deficits in other skills including auditory (processing non-speech sounds), visual, motor and balance are associated with reading difficulties and may therefore have a role in early reading development (e.g. Nicolson, Fawcett & Dean, 2001; Stein & Walsh, 1997). We will summarise a recent longitudinal study into the impact of early sensory, motor and cognitive skills on reading development (Shapiro, Carroll & Solity, submitted). Our study follows on from the work by Carroll et al and Muter et al, and includes a wide range of cognitive, sensory and motor skills in order to examine whether other skills either mediate the influence of oral language, or have a direct, independent influence on reading development.

Methodology

We measured speed of processing, reading and phoneme skills, accuracy of processing, rhyme skills, IQ and memory, motor skills and speech and auditory skills (see Table 1 for details of tests used) in children beginning their Reception year (first year of

[3] The study reported is part of a larger project conducted by L. Shapiro. J. M. Carroll and J. Solity, supported by British Academy award SG-38400 and ESRC award RES-000-22-1401. A full description of the study will be provided in Shapiro, Carroll and Solity (submitted).

formal schooling in the UK) in three mainstream state-funded UK primary schools. Three cohorts of children were tested from two of the schools and four cohorts from the third school (total N = 392; mean age 4 years 6 months). We then collected follow up measures of children's letter knowledge and their word and non-word reading using a range of standardised and non-standardised tests at the end of Reception (see Table 2 for details of tests used). All children remaining at the schools were tested (N = 348; mean age 5 years 2 months). This design enabled us to investigate which baseline skills are directly linked to early literacy outcomes, and which baseline skills have only an indirect influence. Firstly, we report analyses which uncover the key skills at baseline. Secondly, we report analyses indicating which of these baseline skill factors are critically related to literacy outcomes.

Table 1 about here

Table 2 about here

Results

Baseline Skills

Confirmatory factor analyses isolated seven key baseline skill-factors (see Table 1 for a description of these factors). There are three main points to note from the baseline data. Firstly, it is interesting that the best model separated the Reading & Phoneme, Rhyme and the Speech & Auditory factors, indicating that performance on reading and phoneme tasks arose from different underlying processes than performance on rhyme, speech and auditory measures. Secondly, the best model included a single factor for Speech & Auditory skills, indicating that the same underlying processes drove performance on our speech and non-speech tasks, whether production of sounds was involved or not. Thirdly, the best model included separate factors for Speed and Accuracy, indicating that performance on button-press speed measures arose from the same underlying processes, and performance on all button-press response-accuracy measures arose from the same underlying processes.

Literacy Outcomes

Since all word and non-word reading tests were highly correlated (all above .7), we created a composite score for reading. When literacy outcomes were included in our confirmatory factor analyses, the best model included just two direct causal links from baseline skills to literacy outcomes (see Figure 2). Firstly, as expected, children's Reading & Phoneme skills at baseline had a strong, direct influence on literacy outcomes at the end of the year. Secondly, initial Speech & Auditory skills had a direct, independent influence on reading, even once initial Reading & Phoneme skill had been accounted for. No other direct links made any significant improvement to the fit of the model. Nevertheless, all other baseline skills were correlated with the crucial predictive skills (see Table 3).

Discussion

We found that early auditory and speech skills have a direct influence on literacy at the end of the first year of formal schooling. This confirms the importance of oral language, supporting Carroll et al and Muter et al. In contrast, IQ & memory, motor, rhyme, speed and accuracy skills had no direct influence on literacy at this stage of development. However, these skills were correlated with the crucial predictive factors. Therefore children with good motor skills, for example, would be likely to also perform well on the speech and auditory tasks. However, it would be their speech and auditory skills that crucially influenced their literacy development, not their motor skills.

Implications for the Classroom

Speech and auditory measures are the best predictors of early reading development and teachers should therefore focus on the tests that tap these skills in order to make predictions about children's literacy progress in the first year of school. Although it is possible that the causal relationships between baseline skills and literacy may change as reading develops, these early reading outcomes are likely to have a critical impact on children's later literacy success.

Although poor speech and auditory skills may indicate that a child is likely to require additional help in literacy, the specific locus of children's difficulties is not necessarily useful in informing the *content* of the intervention they should receive. Recent research has shown that even successful treatment of auditory processing difficulties does not directly lead to improvements in literacy (McArthur, Ellis, Atkinson & Coltheart, 2008). In addition, Bowyer-Crane et al. (2008) found that an oral language intervention for children with poor oral language at school entry impacted on their vocabulary and grammar but a phonology with reading intervention was much more successful in raising their literacy attainments. In fact, it is widely agreed that the most effective interventions for raising literacy attainments for all struggling readers are those that emphasise phonics instruction and in particular, directly teach the skills that are used in reading (Foorman, Breier & Fletcher, 2003). It is important to note that phonology and phonics are not the only skills that should be taught as part of a broad literacy programme. Oral language interventions may be effective in raising levels of reading comprehension, but the types of skills taught to children with poor oral language (e.g. vocabulary, creating stories, independent speaking in Bowyer-Crane et al., 2008) match those that are normally taught to all children. Overall, children at risk of developing reading difficulties may require additional, more intensive training, but the nature of this training should focus on the same core skills as for normally developing readers. In fact, Shapiro and Solity (2008) suggest that attainments of children at all levels of literacy can be raised using whole-class methods, as long as teachers are trained to differentiate between children, and spend time within each whole-class session focusing on material suitable for different achievement groups.

These first two sections have highlighted the importance of early speech and auditory skills on literacy development. The third issue we address is the long term impact of such skills on children's literacy development in secondary school.

The Continuing Impact of Phonological Awareness Skills in Secondary Schools[4]

Background

Extensive research in the English-speaking-world with pre-school and primary-school children has revealed that the incidence of developmental dyslexia is 10 – 12% (Shaywitz, et al., 1992; Snowling, 2000). Many behavioural studies found core phonological deficits in children with dyslexia (Stanovich & Siegel, 1994). ~~Interestingly, Fletcher and Buckley (2002) found "Children with Downs syndrome demonstrated measurable levels of phonological awareness" (p.11), and that their difficulty in acquiring literacy skills may be due to their hearing and auditory short-~~

[4] The study reported is from a larger project conducted by T.N. Wydell, J. John and R. Kilosia (in preparation) supported by an ESRC-KTP award (R86-P22056) to T.N. Wydell.

term memory deficit (Jarnold & Baddley, 2001). It has also been suggested that dyslexia has genetic (Fisher & DeFries, 2002) and neurobiological (Eden & Moats, 2002) origins.

Further, adults with childhood diagnoses of dyslexia also revealed persistent phonological deficits (Bruck, 1992; Wydell & Kondo, 2003). Felton et al. (1990) found that adults with dyslexia were impaired compared to controls on RAN (Rapid-Automatised-Naming), phonological awareness skills test, and non-word reading. Similarly, Paulesu et al. (1996) found that even well-compensated dyslexic adults showed residual phonological deficits on phoneme deletion and Spoonerising.

Dyslexia research in secondary school children is far less extensive. And yet all dyslexic children experience some form of academic underachievement at school (Hannell, 2004). Fawcett and Nicolson (1995) found that three groups of children with dyslexia with mean ages of 8, 13 and 17 years performed significantly worse than their age-/IQ-matched control groups on sound categorisations (wig-fig-pin) and phoneme deletions, thus showing that phonological awareness deficits persist at least into late adolescence. If phonological deficits are sufficient to cause dyslexia, it is to be expected that adolescents with poor phonological skills would be likely to show literacy difficulties (see Wydell & Butterworth, 1999).

Research Objectives

The purpose of the current study was to compare poor phonological recoder (PPR)-readers and normal-readers on reading skills and Statutory Assessment Test (SAT) scores in order to examine the extent to which phonological awareness skills affect reading skills and SAT scores of these academically-high-achievers in the UK.

Methodology. Firstly, 158 male/female children (aged 14-15) from a state-funded but selective highly academic secondary school in the UK participated in the following classroom tests (in written format): (a) Rhyme-Judgement – WORD (*head – bed*) (Howard & Franklin, 1996)*;* (b) Rhyme-Judgement – NONWORD (*kape - bape*) (Best, 1996)*;* (c) Homophone-Judgement – WORD (*their – there*) (Coltheart, 1980)*;* (d) Homophone-Judgement – NONWORD (*kane – kain*) (Coltheart, 1980)*;* (e) Phonological-Lexical Decision Task – *YES to bran* (Frith, 1996). Secondly, 16 children whose scores on any of these five tests (a – e) fell more than 1.5 SD below the mean of the group as a whole were identified as PPR-readers. 10 (7 male & 3 female) out of these PPR-readers and 16 randomly chosen normal readers as controls undertook further tests (administered individually): (i) Reading-WORD (Schonell, 1960)*;* (ii) Reading-NONWORD (Glushko, 1979)*;* (iii) Spoonerising (Perin, 1983) *(/car/ /park/ -> /par/ /cark/);* (iv) Gathercole's Nonword-Repetition (Gathercole & Baddeley, 1996)*;* (v) Phoneme-Deletion (Stuart, in prep.)

Results and Discussion. Statistical analyses revealed that PPR-readers were significantly worse than the controls as shown in Figure 3 on (i) Reading-WORD ($t(24)=-5.32$, $p<.0001$), (ii) Reading-NONWORD ($t(24)=-3.07$), $p<.005$), (iii) Spoonerising ($t(24)=-2.64$, $p<.01$), and (v) Phoneme-Deletion (only approaching significance, $p=.08$). However, there was no difference between the two groups on NONWORD-Repetition ($p>1$).

As expected from the other studies (e.g., Paulesu et al., 1996), PPR-readers performed significantly worse than the controls on the tests where phonological awareness skills were assessed. The results thus suggested that typical phonological tests (homophone-judgements, rhyme-judgements, NW-reading, Spoonerising, and Phonological-Lexical Decision Task) may still be effective in identifying dyslexia among older and academically high-achievers. The null effect on Gathercole and Baddeley's Nonword Repetition test (1996) was most likely due to the fact that the test was developed primarily to assess young children's phonological skills, and that the test was not sensitive enough for these adolescent individuals.

Interestingly PPR-readers performed significantly worse than the controls not only on reading nonwords (Campbell & Butterworth, 1985) but also words, particularly Schonell's words. ~~This is a new finding.~~

As shown in Figure 4 PPR-readers' performance on SAT-English, SAT-Science and SAT-Mathematics were compared individually with that of the normal readers using z-scores. This is because it has been reported that there is marked individual differences amongst children with developmental dyslexia both in terms of the extent of severity and the nature of difficulties/impairments (Ellis, 1995; Snowling & Griffiths, 2005). The results revealed that the SAT-English scores of six out of ten PPR-readers were significantly worse than those of the controls ($z = -0.85$ for PPR-2, PPR-3, PPR-4, PPR-8, PPR-9 and PPR-10; $p < .001$), and seven PPR-readers had SAT-Science scores significantly worse than those of the controls ($z = -0.85$ for PPR-1, PPR-2, PPR-4, PPR-5, PPR-6, PPR-9 and PPR-10; $p<.001$). However, none of the PPR-readers were significantly worse than the controls in SAT-Maths scores.

Discussion and Implications for the Classroom

Even in a selective and competitive academic environment, where all children appear to be performing well against the national average, we have identified a subset of children with phonological deficits (PPR-readers) that correlate with lower SAT scores in English and Science (PPR-2, PPR-3, PPR-9 and PPR-10 showed lower scores in both English and Science). Further, these children were significantly poorer at reading Schonell words compared to the controls. As Hannel (2004) stated, these children can be considered as academic under-achievers. None of these children were previously identified as dyslexic. Interestingly, these children showed no difference on SAT scores in Mathematics when compared to the normal readers, which indicates that cognitive processes involved in reading may be different from those involved in mathematical operations (a similar pattern of data can be seen in Wydell & Butterworth, 1999).

The current study revealed that "silent dyslexia" exists amongst academic high-achievers. Further, phonological awareness skills tests can be used to identify these children as in other studies (e.g., Bruck, 1992; Fawcett and Nicolson, 1995; Felton et al.,1990; Wydell & Kondo, 2003) and if they can be identified they may benefit from problem-based remediation or training. Treiman and Brown (1983) demonstrated that training in phonological awareness skills with young children had a positive effect on academic grades at school. However, further research needs to be conducted in order to ascertain whether training in phonological awareness skills with the older children or students at secondary schools would be as beneficial as with young children.

The first three sections have highlighted the impact of speech and auditory skills on literacy development, and also on the long term academic achievements of children. The next section will outline assessments that can isolate the specific difficulties children have at all stages of development.

Implications for Assessment and Instruction

In the current paper, we aim to identify valid and reliable assessments that match with current theories of reading and writing and are suitable for students of all ages. Many tests of reading provide a reading 'age' but not a deeper understanding of the individual's literacy difficulties. Matching assessment packages to theories of reading development enhances understanding. We have limited our selection to standardised tests suitable for use across a wide age-range because of the growing number of adults requiring diagnostic assessment as they pursue further and higher education. Although our main focus is on the assessment of reading, we will start by discussing assessments that are available for measuring pre-reading skills. We will then outline the theoretical framework on which reading assessments are based, followed by a discussion of assessments that are suitable for assessing reading in school-age children and adults.

Assessments for Pre-readers

In the earlier sections of the paper, we outlined that speech and auditory skills are crucial predictors of a child's literacy development, and tests that tap into these skills are likely to provide a good indication of a child's literacy potential. However, although these tests are highly predictive of literacy with large samples of children, they will not necessarily be predictive on an individual basis. Importantly, standardised tests have not been developed for use in the classroom specifically to measure speech and auditory processing in pre-readers. Thus, it is difficult to make accurate predictions about individual children's learning needs until they have begun to learn to read. Once a child has received some formal training in reading, phonological awareness tests provide a very accurate prediction of their later literacy success (we outline some of these tests for school-age children in the section on assessments of the non-lexical route, below).

The DEST (Nicolson and Fawcett, 2004) provides a screening test for dyslexia that is suitable for use with 4 to 6 year old children. However, a child's 'at risk' score on this test is based on performance across a wide range of measures. Some of these measures we have shown to be only indirectly linked to literacy (such as memory and motor skills). Thus, it is possible that the DEST taps into non-specific markers for a wide range of developmental disorders, rather than predicting specific literacy difficulties, per se (see White et al., 2006, for a related argument).

Assessments for School-age children and adults

Theoretical Framework

According to Gough (1996) reading comprehension (RC) is the product of word reading efficiency (WRE) and the ability to comprehend language (LC), or RC = WRE x LC. An essential dimension of being able to read is to decode the printed word reasonably rapidly. Inability to do this will lead to effortful reading, undermining capacity to understand what is being read. Gough argues that once this skill is in place, the reader must apply the same skills as required when making sense of language. Though we are broadly in agreement with Gough, we consider that reading comprehension requires a slightly different set of skills to making sense of oral language.

Printed word recognition. We will deal first with word reading efficiency, or printed word recognition. For our theoretical framework we have adopted a dual-route model (Jackson & Coltheart, 2001). This model proposes that words can be recognised in two ways. Firstly, through the *lexical* route, where printed words are linked directly to their meanings. This amounts to a sight word vocabulary and underpins the effortless reading of the skilled and mature reader. Secondly, through the *non-lexical* route, where letters are converted to sounds, involving phonological awareness (involves both segmentation and blending); phonological memory (store sound-based information for short periods) and rapid naming (Wagner, Torgesen, and Rashotte, 1999). Although there are other contemporary theories of reading, essentially, the two dimensions of lexical and non-lexical processes are identified (Hurry and Doctor, 2007).

Comprehension. Whilst poor reading comprehenders tend to be deficient in lower level skills, such as vocabulary and world knowledge, impairments in higher level skills are particularly characteristic. They have difficulties with making inferences, rather than answering literal questions, with integrating information to form a coherent understanding and with comprehension monitoring (Cain, Oakhill, Barnes and Bryant, 2001; Rosenshine, 1980; Oakhill, 1994; Perfetti, Marron & Foltz, 1996; Cataldo & Cornoldi, 1998).

Assessing Printed Word Recognition

Non-lexical route. There is good evidence that of the three areas; non-lexical, lexical and comprehension, the non-lexical route provides the foundation. It is well addressed by existing assessments, reflecting the emphasis on phonological skills in reading research over the last two decades. Two good tests are firstly the *Comprehensive*

Test of Phonological Processing (CTOPP, Wagner Torgesen and Rashotte, 1999), which assesses the key non-lexical skills mentioned above - phonological awareness (elision, blending, non-word repetition), phonological memory (memory for digits) and rapid naming (rapid digit naming and rapid letter naming). Secondly, the *Phonological Assessment Battery* (PhAB, Frederickson, Frith & Reason, 1997) is a UK standardised test for 6-15 year olds, with measures of phonological awareness (alliteration, rhyme and spoonerisms), semantic/phonological memory (fluency), rapid naming and phonological decoding (non-word reading).

Lexical route. There has been much less of a theoretical gaze on the lexical route and this is reflected in the absence of current assessment. *The Test of Word Reading Efficiency* (TOWRE, Torgesen, Wagner & Rashotte, 1999), provides a test of reading fluency. This rapidly administered test assesses both word (*go, dog…have, some*, *now….verbatim*, *awkward*) and non-word reading (*mib, taw, shum*). A poor score on word reading relative to non-word reading indicates difficulties with the lexical route; a poor score on the non-word reading relative to the word reading test is indicative of difficulties with the non-lexical route. One of the TOWRE's strengths as an assessment for teenagers and adults is that it provides an indication of reading under time constraints, indicative of how the reader will cope under exam conditions or when there are deadlines to meet.

Alongside the TOWRE it is useful to use the *Wide Range Achievement Test 4* (WRAT4), an untimed single word test of reading and spelling, to assess performance when there are no time constraints.

Usually, if there is a weakness in the non-lexical route, the lexical route will also be impaired, as the non-lexical route provides the critical foundation for independent reading, which then leads to fluency.

Assessing Reading Comprehension

The assessment of reading comprehension also suffers from being out of the ‘theoretical gaze’. Most reading comprehension tests confound printed word recognition and comprehension. An exception is the *Neale Analysis of Reading Ability* (NARA II, Neale, 1997). The person being assessed reads the passage, but the examiner provides the words the reader cannot decode. However, the main focus is on literal comprehension (for 65% of the questions). For example, comprehension of the text “A black cat came to my house” is probed with the question: “What came to the little boy’s house?” The remaining 35% of questions require only fairly simple inferences. For example, comprehension of the text “A surprise parcel arrived…..Peter looked at the strange stamps” is probed with the question, “How do you know that the parcel came from another country?” Higher order skills are not sufficiently addressed.

Other assessments, such as the Weschler Objective Reading Dimensions (WORD), the Progress in English series and the Edinburgh Reading Test have more questions tapping higher order skills. In the WORD, around 30% of the items assess literal comprehension skills; the other 70% involve simple or complex inference or identifying the main idea of the story. Progress in English utilises authentic texts, with exercises addressing: coherence inferences; vocabulary & language; genre**.** However, in all these tests, comprehension is confounded with decoding. Development is needed in this area.

Implications for Instruction

An obvious remaining issue is how this research relates to instructional practice. It is important to be aware of the practical limitations of research into predictors of literacy. Simply because speech and auditory skills are crucial predictors of reading doesn’t mean we should train these skills specifically. Instead, the majority of the research on instruction suggests that the best skills to teach are those that are as close as possible to the actual process of reading itself (Foreman et al., 2003; Shapiro & Solity, 2008).

Nevertheless, the research we reported on OM does suggest that awareness of a child’s medical history would allow teachers to ensure that the child receives the best possible auditory input, thus potentially alleviating some of their speech processing difficulties. However, further research would be needed to examine the impact of changes to teachers’ normal practice on the literacy outcomes of these children. In addition, it may be the case that certain forms of highly intensive phonics instruction (e.g. Fuchs et al., 2001; Hatcher et al., 2006; Shapiro & Solity, 2008) may also alleviate some of the problems experienced by children with OM, and also other children with poor speech and auditory skills.

The long term impact of phonological awareness difficulties on children’s academic achievement highlights how crucial it is for children to develop these skills as soon as possible in their education. It is very likely that the secondary school children identified as having poor phonological skills had experienced difficulties with phonological awareness throughout their schooling. Perhaps their difficulties were left un-noticed because a decade ago, when they were learning to read, we were less aware of the importance of phonological skills. Thus, standard teaching practice in schools a decade ago did not include such intensive phonics training as now. In addition, perhaps teachers were less well equipped to meet the needs of children who were experiencing reading difficulties. Clearly, it would have been much easier to remediate their difficulties at an earlier age (e.g., see Foorman et al., 2003; Treiman & Brown, 1983) since it is likely that these children will have developed compensatory strategies to allow them to overcome their difficulties with the non-lexical route. However, more research is needed to investigate whether phonological interventions could successfully improve the literacy skills of older children.

Summary and Conclusions

The current paper has emphasised the importance of speech and auditory skills in early literacy development. In the first section, we described a potential cause of early speech difficulties: early onset otitis media. We highlighted the consequences of early speech processing difficulties on literacy development and made recommendations for good classroom practice to alleviate some of these difficulties. In the second section, we reported that early speech and auditory skills were crucial predictors of normal literacy development, whereas other skills were only indirectly linked. In the third section, we illustrated the consequences of long term phonological difficulties on literacy and general academic performance. It is striking that even high achieving children can be held back by difficulties in their phonological awareness at such a critical time in their education. In the final section, we described how research into literacy development has led to the development of a range of assessments that can be used to specify the particular difficulties individuals are experiencing with literacy, and we recommended tests that can be used to conduct accurate assessments at a wide range of ages, from the beginning of school through to adulthood.

Consistent and accurate assessment is critical for both research and practice. A greater consistency in the literacy assessments used across research studies will allow more accurate identification of the crucial skills that predict reading at different stages of development, and further our understanding of the causes of reading difficulties. In the classroom, accurate diagnostic assessment offers a gateway to services, and informs teaching decisions. Linking assessments to theoretical frameworks and research knowledge improves the applicability of diagnostic information. However, existing assessments reflect the concentration on phonology in reading research over the last two decades. Thus, tests of the non-lexical route are well developed whereas assessment of the lexical route and reading comprehension are less well addressed. Ultimately, a more theoretically based use of assessment will enhance teachers' planning of teaching programmes for students with reading difficulties and ensure that children's learning needs are more accurately identified.

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Table 1

Key Baseline Skill Factors Isolated in Longitudinal Study of Early Predictors of Literacy

Factor	Measures
Speed	1. Computer-based button press task: child pressed one button when a dinosaur present on screen, another button when dinosaur hidden, no distractors; score is speed of button pressing (button press RT); 2. Gerhardstein & Rovee-Collier (2002) visual search task: child searched for a target dinosaur among distractors; score is time taken to find dinosaur, per distractor (visual search slope)
Reading & Phoneme	1. No. letters read correctly by sound or name (letter knowledge); 2. no. of 100 most frequent words read correctly (sight words); 3. digit naming (from the Dyslexia Early Screening Test: DEST; Fawcett & Nicolson, 1996); 4. phoneme isolation (DEST) British Ability Scales word reading test A (BAS; Elliott, Murray & Pearson, 1983) and Neale Analysis of Reading Ability (NFER passage reading; Neale, 1997) not included (scores at floor)
Accuracy	1. Visual search accuracy (target present acc); 2. visual search accuracy (target absent acc); 3. Accuracy from button press task (button press acc); 4. auditory discrimination based on Tallal's, 1980, auditory temporal processing task: child learns to associate associating two buttons with two sounds, score is accuracy in test phase (auditory discrim)
Rhyme	1. Rhyme detection from the Phonological Abilities Test (PAT; Muter, Hulme & Snowling, 1997; PAT rhyme); 2. Rhyme detection from the

	DEST (DEST Rhyme)
IQ & Memory	1. Non-verbal IQ (Ravens; Raven et al., 1993); 2. Verbal IQ (from the British Picture Vocabulary Scale: BPVS; Dunn, Dunn, Whetton & Burley); 3. Working memory (from the DEST; digit span)
Motor	1. Bead threading task from the DEST; 2. Annett's (2002) peg board (created composite measure of left & right RT, hand difference not used-correlations very low); 3. shape copying from the DEST DEST Postural stability not included (correlations very low with other measures)
Speech & Auditory	1. Phonological discrimination from the DEST (phoneme discrim); 2. speech rate from the PAT; 3. Nonword repetition: child repeated nonwords from the Phonological Assessment Battery (PhAB; Frederickson, Frith & Reason, 1997) presented on a cassette recording (nonword rep); 4. rapid naming from the DEST; 5. Sound order task from the DEST; 6. Auditory Temporal Processing (ATP) based on Tallal (1980): child repeated back sequences of sounds

Table 2

Outcome Measures used in Longitudinal Study of Early Predictors of Literacy

Measure	Description
Letter sound knowledge	No. letters read correctly as sounds or names (/26)
Reading	1. Non-word reading fluency (non-words read in 30s); 2. PhAB non-word reading test; 3. BAS word reading test A; 4. NFER passage reading (no. words read); 5. Sight word reading (100 most frequent words)

Table 3

Correlations among Baseline Skills in Model of Early Predictors of Literacy

	Speed	Reading & Phoneme	Accuracy	Rhyme	IQ & Memory	Motor
Speed	.					
Reading & Phoneme	0.39	.				
Accuracy	0.22	0.36	.			
Rhyme	0.23	0.54	0.23	.		
IQ & Memory	0.47	0.78	0.59	0.67	.	
Motor	0.48	0.53	0.47	0.51	0.71	.
Auditory & Speech	0.62	0.84	0.55	0.52	0.80	0.67

Figure Captions

Figure 1. WORD reading test correct scores and composite PhAB z-scores for OME group with persistent episodes (6+ years of age), OME group with last episode up to 5 years of age, and control group.

Figure 2. A Structural Equation Model of the predictive power of baseline skill groups on children's literacy outcomes at the end of their first year of formal schooling.

Figure 3. Proportion correct on reading and phonological tasks of PPR-Readers compared to that of the Controls.

Figure 4. Performance of PPR-Readers compared to the Controls on SATs.

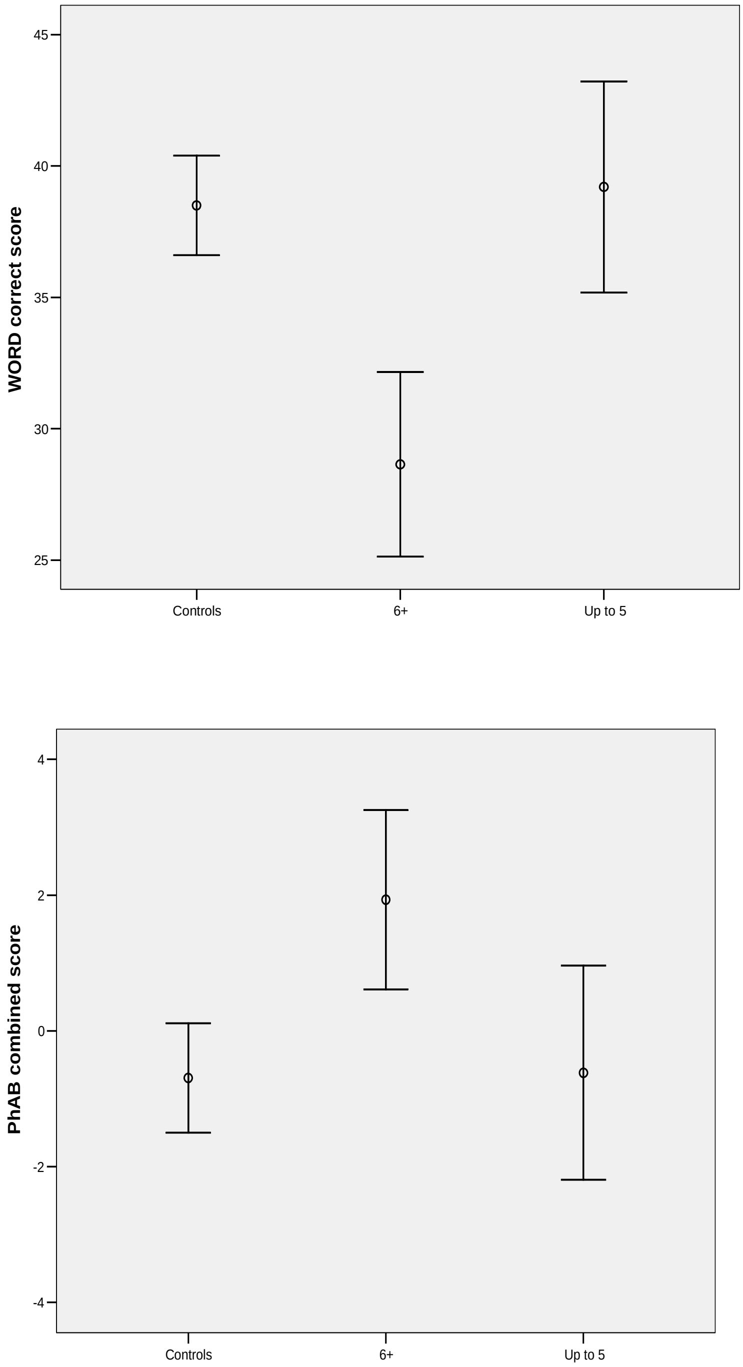
45
40
35
30
25
WORD correct score
Controls
6+
Up to 5
4
2
0
-2
-4
PhAB combined score
Controls
6+
Up to 5

Figure 1

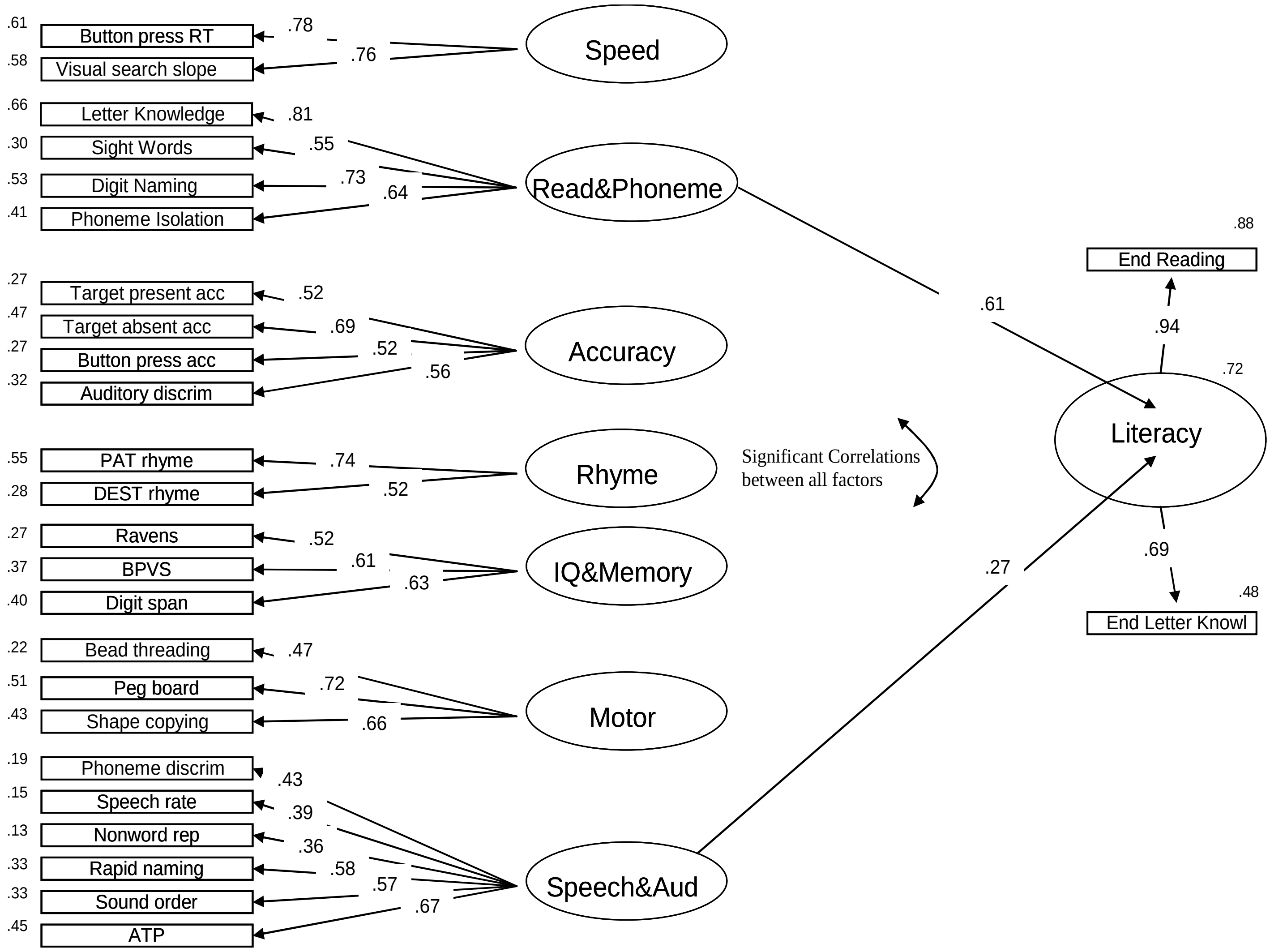

Figure 2

Note. This was the best fitting model out of all theoretically plausible alternatives, X2 =418.66 (276), p <.001, NFI=.85, IFI=.95, CFI=.94, RMSEA=.036 (.029-.043). All correlations between baseline factors were significant (estimates shown in Table 3). Factor loadings are represented by single headed arrows, with standardised regression weights shown. Squared multiple correlations for the baseline observed variables are given at the far left of the figure, and squared multiple correlations for the outcome observed variables and the endogenous factor are given at the far right of the figure.

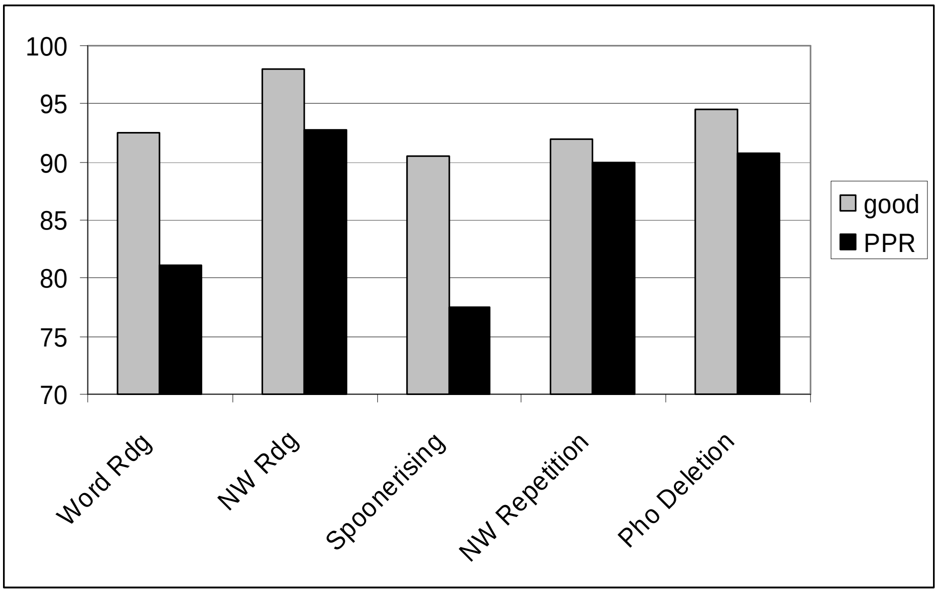
100
95
90
85
80
75
70
good
PPR
Word Rdg
NW Rdg
Spoonerising
NW Repetition
Pho Deletion

Figure 3

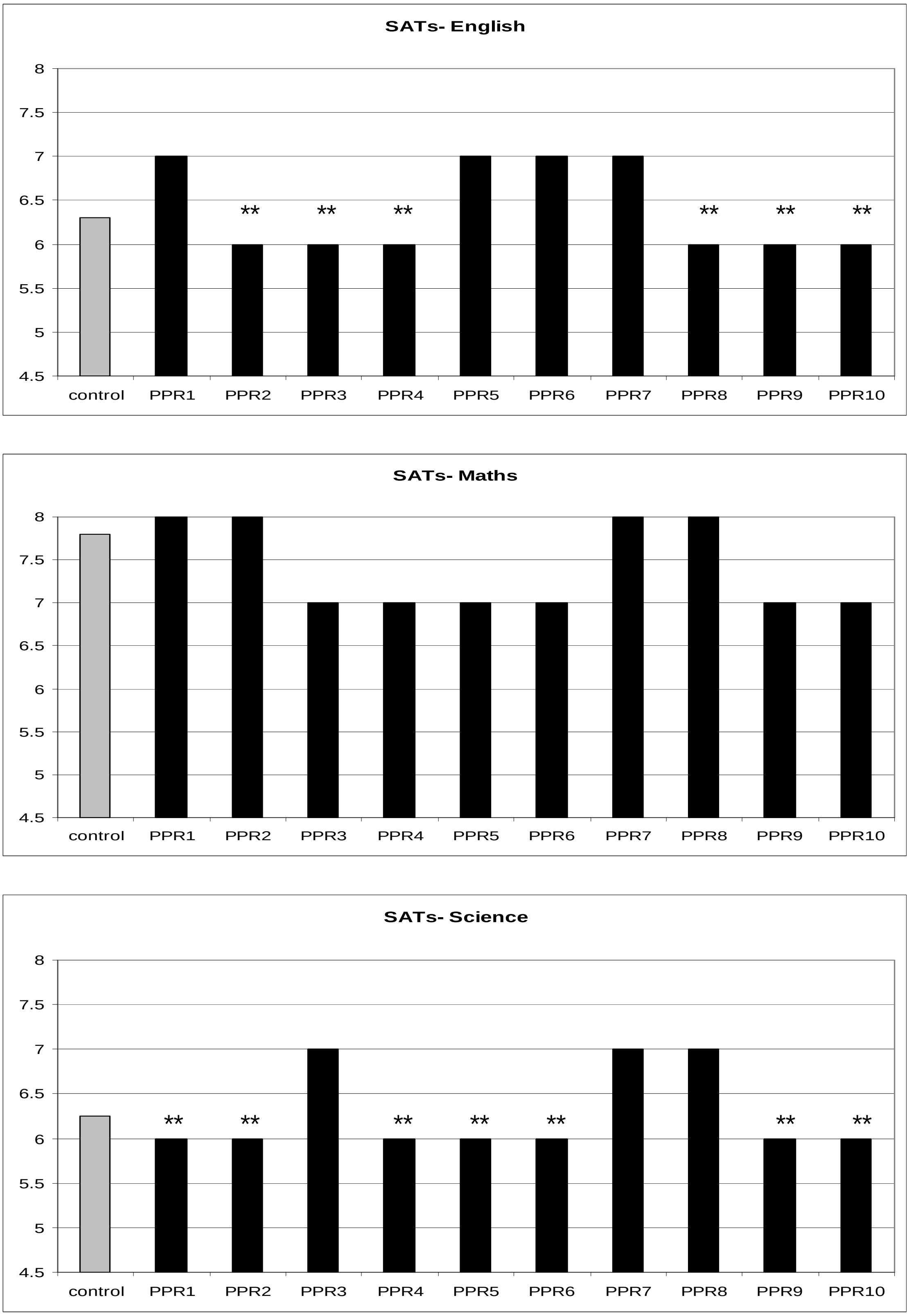
SATs- English
8
7.5
7
6.5
6
5.5
5
4.5
**
control
PPR1
PPR2
PPR3
PPR4
PPR5
PPR6
PPR7
PPR8
PPR9
PPR10
SATs- Maths
SATs- Science

Figure 4

Note. ** $p < .01$