Job No. 9730 Mendip Communications Ltd Page: 443 of 468 Date: 18/7/03 Time: 7:35am Job ID: LANGUAGE 006949

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The dissociation of word reading and text comprehension: Evidence from component skills

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In this paper, we discuss the relative contribution of several theoretically relevant skills and abilities in accounting for variance in both word reading and text comprehension. We present data from the first and second waves of a longitudinal study, when the children were 7 to 8 years, and 8 to 9 years old. In multiple regression analyses, we show that there is a dissociation between the skills and abilities that account for variance in word reading, and those that account for variance in text comprehension. The pattern of results is very similar at both time points. Significant variance in comprehension skill is accounted for by measures of text integration, metacognitive monitoring, and working memory. By contrast, these measures do not account for variance in word reading ability, which was best accounted for by a phoneme deletion task. The implications of these findings for our understanding of the development of reading ability, children's problems in text comprehension and for remediation will be discussed.

INTRODUCTION

There is now a very extensive literature on children's reading development and reading difficulties. However, for the most part, this work concerns word level decoding. Of course, reading could not take place if the reader

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Job No. 9730 Mendip Communications Ltd Page: 444 of 468 Date: 18/7/03 Time: 7:35am Job ID: LANGUAGE 006949

were unable to decode the words on the page but, although single-word reading is crucially important, it is not sufficient. This relation between decoding and comprehension has been captured neatly by Gough and Tunner (1986) who proposed a model in which ''reading'' is viewed as the product of word decoding and language comprehension. Thus, if the value of either of the components is zero (i.e., the child cannot recognise any words, or has no language comprehension), reading ability will also be zero. This model has since been empirically substantiated (Gough, Hoover, & Petersen, 1996), strongly suggesting that there are two main components to reading. Recently, many have argued that single-word decoding and comprehension processes are relatively independent (Perfetti, 1985). Indeed, Perfetti, Marron, and Foltz (1996) list ''lexical processes'' as only one of a number of components in reading comprehension. Pazzaglia, Cornoldi, and Tressoldi (1993) report factor analyses, from their own and others' studies, which demonstrate substantial independence between decoding and comprehension. In their own work, they find that different cognitive abilities relate to reading comprehension and to decoding. For instance, they showed that, in the early school grades, performance on measures of linguistic ability and long-term memory were related to comprehension, but not to decoding speed or accuracy, whereas measures of visual and auditory analysis skills were strongly related to speed and accuracy of decoding, but not to comprehension.

Furthermore, although in the normal population single-word reading and comprehension skill are in general highly correlated, a substantial minority of children develop the former but not the latter skill. Our own earlier work (Cain & Oakhill, 1996; Cain & Oakhill, 1999; Yuill & Oakhill, 1991) and that of Stothard and Hulme (1992) has shown that skilled and less-skilled comprehenders differ in a number of reading-related skills but, in particular, that skilled comprehenders build better-integrated and informationally richer text representations.

If word reading and comprehension skill make independent contributions to overall reading ability, then it should be the case that each is based on different underlying skills and abilities. In addition, the developmental path of each component might also be expected to be, at least to some extent, independent of that of the other, and be predicted by different subskills. It is important to clarify what these underlying skills are, in order to understand the development of skilled reading and to inform remediation. In this paper, the first of these two issues is addressed, by assessing which particular skills and abilities account for distinct variance in word reading and comprehension. There follows a brief discussion of the subskills that might be expected to be related to either word reading, or text comprehension, or both.

There is now a wealth of evidence that the development of successful decoding is dependent on phonological skills: children with good word reading skills have a better awareness of the sound structure of words (phonological awareness) than do children who are poor word readers (Stanovich & Stanovich, 1999; Wagner, Torgeson, & Rashotte, 1994). An indirect link between phonological skills and reading comprehension is plausible because, if children are having difficulty in decoding words, then their short-term memory may become overloaded and their ability to parse and comprehend sentences may be affected (Shankweiler, 1989). Whether or not phonological skills are related to reading comprehension in fluent readers is less clear: Stothard and Hulme (1996) did not find differences between skilled and less-skilled comprehenders in their levels of phonological ability using a range of assessments. We included measures of phonological awareness in the current study, predicting that they would explain unique variance in decoding ability but would not share a direct relation with reading comprehension skill.

Short-term memory might be expected to play a role in reading, and in comprehension in particular, because of its role in sentence parsing and text integration. In previous studies we have found that skilled and less-skilled comprehenders are not differentiated by their performance on traditional tests of short-term memory (e.g., digit span and word span: Oakhill, Yuill, & Parkin, 1986). Thus, less-skilled comprehenders' ability to repeat back sentences and even short stories is commensurate with that of good comprehenders. However, poor comprehenders experience difficulties with working memory tasks (i.e., memory tasks that require them to switch between storage and processing functions). Since Daneman and Carpenter's (1980; 1983) pioneering work, many studies have shown that, for college students, a measure of ''reading span'' correlates with many measures of reading comprehension such as remembering facts, detecting and recovering from semantic inconsistencies, and resolving pronouns, especially those with distant antecedents. The relation between working memory capacity and reading comprehension is also found in populations of schoolchildren, though the link tends to be stronger with tasks requiring the processing and storage of verbal materials (words and sentences) than with those using numerical materials (Seigneuric, Ehrlich, Oakhill, & Yuill, 2000).

Word knowledge is highly correlated with reading comprehension ability in both children and adults (Carroll, 1993), thus we would expect vocabulary knowledge to explain a sizeable proportion of variance in reading comprehension skill at each assessment point in this study. However, the precise relation between the two is not clear. Clearly, knowledge of word meanings is related to the ability to understand text, and if there are too many unknown words in a story, it is easy to lose the sense of the whole. However, limited vocabulary knowledge does not always impair comprehension (Freebody & Anderson, 1983, cf. Wittrock, Marks, & Doctorow, 1975) and, conversely, vocabulary knowledge per se does not appear to be sufficient to ensure adequate comprehension of larger units of text (Pany, Jenkins, & Schreck, 1982). As already noted, several researchers have demonstrated that children can experience text comprehension difficulties even when vocabulary knowledge is controlled for (Ehrlich & Remond, 1997; Oakhill, Cain, & Yuill, 1998; Stothard & Hulme, 1992). Therefore, it is not clear whether vocabulary knowledge would explain significant variance in reading comprehension skill after variables that are highly correlated with vocabulary, such as verbal IQ, have been taken into account.

Some abilities, like syntactic skills, might be expected to relate to both components of reading. First, syntactic knowledge may aid word recognition if children can use the constraints of sentence structure to supplement their decoding. Indeed, Rego and Bryant (1993) showed that children's early syntactic awareness was strongly related to their later ability to use context to read novel words. Second, grammatical knowledge may be related to comprehension, because understanding at the level of the sentence is obviously fundamental to understanding at higher levels. More specifically, grammatical awareness may help children to detect and correct reading errors and, thus, enhance their comprehension monitoring. Willows and Ryan (1986) found that syntactic knowledge was related to both components of reading ability, reading comprehension and decoding in 6- to 8-year-olds, even after vocabulary ability and non-verbal IQ had been taken into account. However, Bowey and Patel (1988) found that syntactic ability did not account for significant variance in reading comprehension and accuracy in 6-year-olds after individual differences in vocabulary had been taken into account. Evidence from Tunmer and colleagues suggests that there might be a reciprocal relation between reading ability and syntactic ability. Tunmer (1989) assessed children's syntactic abilities at the end of the first year of school and then a year later. Performance on the syntactic measure predicted both word decoding and listening comprehension, and these two skills in turn predicted reading comprehension. Thus, the weight of the evidence suggests that syntax might predict additional variance in both decoding and reading comprehension, after other general ability measures have been taken into account.

Although a weak link is generally found between general intellectual ability and reading ability, most studies of comprehension difficulties in children have not related reading comprehension to general intellectual ability. One notable exception is Stothard and Hulme (1996) who report differences between good and poor comprehenders on measures of verbal but not performance IQ. This finding led them to propose that variation in comprehension skill can largely be accounted for by variation in verbal IQ. Thus, it is important to determine whether the component processes we are particularly interested in are related to reading comprehension skill even when measures of general intelligence are taken into account.

The majority of work into comprehension development in recent years has focused on impaired development, by comparing skilled and less-skilled comprehenders on specific experimental tasks (Cain & Oakhill, 1996, 1999; Ehrlich & Remond, 1997; Nation & Snowling, 1998, 1999; Stothard & Hulme, 1992; Yuill & Oakhill, 1991). In much of this work, researchers have selected children using tests of word recognition and comprehension, so that skilled and less-skilled comprehenders are matched on a measure of single-word reading or non-word decoding, and on the ability to read words aloud in context, but differ markedly in their ability to answer questions about text. Such groups differ in their ability to make inferences, integrate information in text, understand story structure and monitor understanding (Cain & Oakhill, 1996, 1999; Cain, Oakhill, Barnes, & Bryant, 2001; Ehrlich & Redmond, 1997; Yuill & Oakhill, 1991). However, it could be argued that such less-skilled comprehenders are ‘‘special cases’’ and that in the general population comprehension is more closely related to single-word decoding skill, so that such dissociations do not apply. The question we address in this paper is: Given that the understanding of a text depends on building a mental model of the situation represented in that text, is this ability normally inextricably interrelated with lower-level reading processes in children? Or, are there skills that contribute to the construction of the text representation, that are not predictors of reading ability more generally?

In the present paper, we assess the relevant contribution of the various abilities we have shown to be related to comprehension skill in primary-age children, to see whether they make distinct contributions to comprehension, over and above the contributions of age and general ability. A possible criticism of our approach is that some of the component measures of comprehension will be related to reading comprehension simply because two measures of comprehension are being correlated. However, ‘‘reading comprehension’’ is a largely unanalysed construct and, as we point out, many different factors may contribute to high performance on standardised measures of comprehension. Thus, in order to find out which skills and abilities make important contributions to comprehension, and the relative strength of those contributions, we attempt to analyse this construct. Of course some of the component measures will be measures of (aspects of) comprehension. But, we consider that it is of crucial importance to know which of these subcomponents predict variance in comprehension skill. For instance, performance on a comprehension test will require contributions from both literal memory and inferential skill, but it is not known whether these are equally important. Our previous research would suggest not. The present study will permit us to address precisely such questions. In addition, it is very difficult to know how to improve comprehension if all that is known is that comprehension skill is the ability to do well on comprehension tests. One needs to have information about which components of comprehension are failing (e.g., literal or inferential skills) because it is much easier to see how such components (if causally implicated) could be trained than to see how the unanalysed ability (performance on a comprehension test) could be trained. Other authors take a similar approach. Indeed, some accounts of comprehension focus on those skills that contribute to the meaning-construction aspects of the task. For example, Palinscar and Brown (1984) identified six different component skills which, they claim, make up comprehension ability, including the activation of relevant background knowledge, generation of inferences, and monitoring of both ongoing comprehension and the internal consistency of the text.

In addition, the present study will enable us to establish whether there is a distinct set of skills and abilities that predict single-word reading, but not comprehension skill. The concern here is not with between-group comparisons, but with the investigation of the relative contribution of several theoretically relevant skills and abilities to the prediction of both single-word reading and text comprehension skill in a relatively unselected population (see below for selection criteria).

In summary, we have included in this study a number of measures that we know differentiate between groups of skilled and less-skilled comprehenders, and that have previously been considered as important components of comprehension skill in adults (Perfetti, Marron, & Foltz, 1996): inference and integration skills (Cain & Oakhill, 1999; Cain, Oakhill, Barnes, & Bryant, 2001; Oakhill, 1982, 1984), comprehension monitoring (Ehrlich, 1996; Oakhill & Yuill, 1996; Oakhill, Hartt, & Samols, 1996), story structure understanding (Cain & Oakhill, 1996) and working memory (Daneman & Carpenter, 1980; Yuill, Oakhill, & Parkin, 1989); and a number of other assessments: IQ, syntactic, and phonological skills.[1] The ultimate aim of our project (though this is beyond the scope of the present paper) is to explore the stability and consequences of comprehension problems, and to assess which skills and abilities are potentially causally related to comprehension skill.

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[1] Information about the non-standard assessments, and details of how these were scored, can be obtained from either of the first two authors.

METHOD

Participants

The participants in this study were taking part in a longitudinal investigation of reading development. At the first time point, the population comprised 102 7- and 8-year-olds. The population was relatively unselected, except that children who were extremely good readers, or extremely poor readers, were excluded from the sample (all children included in the study had word reading skills that were within 18 months of their chronological age). The very poor readers were excluded from the study because it was envisaged that they might have problems with some of the tasks; the very good readers were excluded because we expected that their reading ability would be beyond the scale of the Neale Analysis (13 years), the test used to measure word accuracy and reading comprehension, by the end of the study. The teachers were asked to screen out all children who did not speak English as their first language, and/or had any known behavioural, emotional, or learning difficulties. The progress of the sample of 102 children will be followed up until they are 10–11 years old, but in the present paper we report data from the first two test points only.

Assessments

Reading ability

The children were given two assessments of reading at each time point: the Gates-MacGinitie Vocabulary subtest, Level 2, Form K (Gates & MacGinitie, 1989) and the Neale Analysis of Reading Ability: Revised (Neale, 1989). The Gates-MacGinitie test requires the child either to select one of four words to go with a picture (in the test suitable for 7 to 8-year-olds) or to select a synonym of a given word from one of four options (8 to 9-year-olds). Thus, it acts as a measure of silent word recognition out of context, and provides an index of the child's vocabulary. As part of the initial screening process, children were assessed individually on the Neale Analysis of Reading Ability: Revised (Neale, 1989). The Neale Analysis provides measures of reading accuracy (word recognition in context), comprehension (assessed by ability to answer a series of questions about each passage), and rate (calculated across all passages as the average number of words read per minute). The age and reading ability of the participants at the beginning of the study are shown in Table 1.

Vocabulary

In addition to the Gates sight vocabulary test, we also assessed the children's receptive vocabulary using a more sensitive, individually-

Job No. 9730 Mendip Communications Ltd Page: 450 of 468 Date: 18/7/03 Time: 7:35am Job ID: LANGUAGE 006949

TABLE 1
Characteristics of participants at the beginning of the longitudinal study ($n = 102$)

	Age	*Gates*	*Neale accuracy*	*Neale comprehension*	*Neale rate*
Mean	7 y 6 m	34.2	7 y 10 m	7 y 2 m	8 y 8 m
Range	86–98 m	26–42	77–108 m	63–119 m	65–156 m

administered test, the British Picture Vocabulary Scales (Dunn, Dunn, Whetton, & Pintillie, 1982). This test (the British equivalent of the Peabody Vocabulary Test) is widely used in the UK. In this assessment, the test administrator says a word and the child has to point to one of four pictures—the one that is a picture of the word. The raw scores from this test were used in the analyses below.

Phonological awareness

To explore the relation between phonological skills and aspects of reading ability, we gave the children two different measures of phonological awareness. We used shortened versions of tests we have developed, full details of which, including the testing procedure, can be found in Cain, Oakhill, & Bryant (2000).

The phoneme deletion task. In this task, the children were asked to say words missing out a specified phoneme: e.g. ''say 'brake' without the 'ruh' sound in it'' (the correct response is 'bake'). At Time 1 all the targets were real words. At Time 2, all of the test items were nonwords to make them appropriately difficult for the older children. At each time point, there were 24 items in total, half of which required deletions near the beginning of the word, and half of which required deletions near the end. There were two practice items for each deletion type, and items were blocked by type.

The odd-one-out task. Children had to specify which of four words in a list started with a different sound from the others: e.g., ''plum, plane, *drum*, plod'', or which ended with a different sound: e.g., ''sand, hand, band, *sack*''. At Time 1, there were 32 items in total, with 8 items of 4 different types: whole onset, whole rime, part onset, and part rime. The children received two practice items of each type before the relevant test items. Items were blocked by type. At Time 2, all of the items were nonwords and there were two conditions only: part onset and part rime. There were eight items of each type, again preceded by two practice items.

Working memory

In the present investigation we included two assessments of working memory: one required the processing and storage of digits and the other the processing and storage of sentences and words. We refer to these tasks as ‘‘digit working memory’’ and ‘‘verbal working memory’’, respectively. There were three trials at each level of difficulty: two, three, or four final items. The children received two practice items at each of the difficulty levels, and the tasks were presented in ascending order of difficulty. The tests were identical at Time 1 and Time 2.

Comprehension of complex sentences

The children’s syntactic abilities were assessed using the Test for Reception of Grammar (TROG: Bishop, 1982). In this assessment, the test administrator reads a sentence aloud, and the child is asked to point to one of four pictures that ‘‘goes with what I say’’. The sentences vary from the very simple to the complex (embedded relative clauses, for example). Because our previous work has shown that all the children of this age are able to do the easiest items on the TROG, only blocks L, N, O, Q, R, S, T (the seven most difficult) were administered to the current sample. There were four items in each block. A reduced set of blocks N, O, Q, R, S, T of the TROG were administered at Time 2. The raw scores from this test (number of individual items correct) were used in the analyses.

General intellectual ability

We included measures of both verbal and non-verbal intelligence at Time 1 only, assessed by the WISC-R (UK edition). The verbal IQ measures were pro-rated from two subtests: Vocabulary and Similarities. The non-verbal (performance) IQ measures were pro-rated from two subtests: Block design and Object assembly. The percentage correct raw scores were used in the analyses that follow.

Specific comprehension subskills

We also included several tasks designed to measure specific comprehension skills which we have found, in previous studies, to be related to comprehension skill. We included an assessment of these skills in three broad areas: text integration and inferential processing; understanding of story structure; comprehension monitoring. A brief description of the tasks used to assess each of these skills is given below.

To assess the children’s *inference* and *integration* skills at Time 1, we used the constructive inference task from Oakhill’s (1982) study. In this task, the children listen to eight short (three-line) texts, and are then asked to state whether or not given sentences were ones that occurred in the texts they had been read. For each text, there were four test sentences of three types: two sentences that had actually been presented (literal information), one sentence that combined information in the story in a manner that was consistent with the overall meaning (valid inferences) and one that combined information in a similar manner, but in a way that was not compatible with the overall meaning of the text (invalid inferences). We used the number of correct acceptances of valid (literal and valid inference) items minus the number of acceptances of invalid inferences (to control for guessing) as an index of the child's ability to integrate information in short texts.

The assessment of constructive inference used at Time 1 was the only assessment that we decided to change substantially at Time 2. The "false memory" paradigm is subject to problems of guessing and response bias. Thus, to assess the children's inference and integration skills at Time 2, we used stories with open-ended questions that tapped both literal and inferential information, which were taken from a study by Cain and Oakhill (1999). These stories were individually administered, a further methodological improvement. There were three stories, each with two literal and four inference questions, preceded by one practice story.

To assess the children's knowledge of story structure we used two different measures because we were not sure of the best manner to assess this ability quickly but reliably. We used a measure that we have tried before: explaining the purpose of story titles, and one new measure which we considered might be a more general assessment of understanding of text structure—a story anagram task.

A previous study (Cain, 1996) has shown that skilled and less-skilled comprehenders differ in their ability to explain the purpose of story titles—i.e., to say what sort of information is included in titles, and why. We used the same question to assess children's understanding of the purpose of titles in the present study. First, the children were simply asked: "What can the title of a story tell us about that story?" All children were then asked three direct questions, each of which focused on either character, setting, or event information. For example: "What about *The Secret Island*? What does that title tell us about that story?" The titles task was extended at Time 2 by asking the children what the beginnings and endings of a story could tell you about the story, in addition to asking for their views on the purpose of a title.

The story anagram task was not derived from previous work of our own, but has been used to assess the development of children's understanding of story structure (Stein & Glenn, 1982). We developed a story anagram task, in which the children were given a series of three short (six-sentence) stories, which had been cut up into their constituent sentences, and the sentences randomised. Their task was to arrange the sentences in the correct order, so that the story made sense. At Time 2, the story anagram task was made more difficult by constructing three new stories, which were eight, rather than six, sentences long. This task was administered to small groups.

The third comprehension subskill in which we were interested was comprehension monitoring. We measured this skill by asking the children to read short stories, some of which contained conflicting information. At Time 1, the children's task was to read the stories aloud, and to underline any parts that did not make sense. They were then asked to explain why they had underlined those particular parts. The comprehension monitoring task was administered to the children in small groups at Time 2, rather than individually. At each time point, children read four inconsistent and two consistent stories.

At Time 2, in addition, we included an assessment of the children's mathematical abilities. The task comprised 20 questions selected from the NFER-Nelson Maths 9 test, which is intended for rising 9s. We selected the questions that required the least reading, so that children's performance on the maths test would not be limited by their decoding skill. This test was administered to the children in small groups.

RESULTS

The reliability of the different experimental measures was assessed by calculating Chronbach's Alpha over items. In most cases the reliability coefficient was good or very good (.60–.80). However, the measure of inference and integration at Time 1 produced an Alpha level of .48 (over all 24 items[2]). We had other concerns about this task, as mentioned above, and it was replaced with a different assessment at Time 2.

Descriptive statistics (means and SDS) for all the measures at Time 1 and Time 2 are shown in Table 2. None of the measures suffered from floor or ceiling effects and there was a reasonable range of scores for each, so all analyses were conducted on the raw data. First, we looked at the inter-correlations between the measures, and then we went on to conduct multiple regression analyses to see which of the measures best account for variance in comprehension skill, and which account for variance in single-word reading ability.

[2] It should be noted that the items were (intentionally) not homogeneous, but there were too few items of each of the three types to get reliable assessments of homogeneity within type. Thus, it is not really surprising that the Alpha level is rather low.

TABLE 2
Descriptive statistics at Times 1 and 2

	Time 1			Time 2		
	N	*Mean*	*SD*	*N*	*Mean*	*SD*
Age	102	90.51	3.28	96	103.41	3.16
Accuracy	102	40.32	5.63	96	55.85	10.19
Comprehension	102	12.32	3.95	96	16.66	4.89
Rate	102	65.67	17.70	96	78.23	14.05
Gates	102	34.30	4.63	96	31.92	6.52
BPVS	102	102.99	9.50	92	105.17	8.80
VIQ	102	52.06	10.85	–	–	–
PIQ	102	52.48	12.48	–	–	–
TROG	102	21.61	2.67	92	18.92	2.04
Deletion	102	18.60	3.82	92	16.64	4.21
Odd-one-out	102	18.06	4.76	92	8.63	3.87
Integration/inference	102	14.84	3.75	92	14.62	2.76
Literal	–	–	–	92	8.39	1.83
Monitoring	102	14.54	3.10	92	5.18	.85
Anagram	101	.80	.16	92	.867	.08
Titles	102	2.93	1.15	92	3.34	1.28
WM digit	101	10.68	3.05	92	16.77	4.18
WM verbal	102	11.30	3.05	92	16.39	5.77
Maths	–	–	–	94	7.50	2.92

Key: Age – chronological age; Accuracy – Reading Accuracy from the Neale Analysis (raw scores); Comprehension – Reading Comprehension from the Neale Analysis (raw scores); Rate – Reading rate from Neale Analysis (raw scores); Gates – Gates vocabulary subtest (Level 2) (raw scores); BPVS – British Picture Vocabulary Scales (standardised scores); VIQ – Verbal IQ (WISC–R, standardised scores, Time 1 only); PIQ – Performance IQ (WISC–R, standardised scores, Time 1 only); TROG – Test for Reception of Grammar (syntax); Deletion – phoneme deletion; Odd-one-out – odd word out task; Integration – integration score (Time 1 only); Inference – correct inference responses (Time 2 only); Literal – correct literal responses (Time 2 only); Monitoring – comprehension monitoring; Anagram – story anagram task; Titles – knowledge about titles; WM digit – digit working memory task; WM verbal – verbal working memory task (sentence span); Maths – NFER-Nelson Maths 9 test (selected items, Time 2 only).

Note: This table shows scaled scores for BPVS and IQ measures, though raw scores were used in the correlational and regression analyses (because age was controlled for independently).

Intercorrelations between measures

The overall correlation matrices for Times 1 and 2 are shown in Tables 3 and 4, respectively. Because of the large number of correlations, a significant level of .01 was adopted.

The overall pattern of correlations between the variables was very similar at both time points. Neale comprehension was strongly correlated

Job No. 9730 Mendip Communications Ltd Page: 455 of 468 Date: 18/7/03 Time: 7:35am Job ID: LANGUAGE 006949

TABLE 3
Correlations between variables at Time 1

	Neale acc.	*Neale comp.*	*Neale rate*	*Gates*	*BPVS*	*VIQ*	*PIQ*	*TROG*	*Del.*	*Odd-one-out*	*Integ.*	*Moni-toring*	*Ana-gram*	*Titles*	*WM digit*	*WM verbal*
Age	.017	.099	–.067	.099	.181	.029	.172	.266*	.002	.021	.122	.136	.022	–.083	.111	.055
Neale accuracy	–	.145	.513**	.684**	.105	.236	.131	.157	.366**	.106	.143	.096	.205	.056	.118	.018
Neale comprehension		–	.121	.228	.442**	.417**	.199	.395**	.028	.525**	.415**	.504**	.402**	.552**	.062	.378**
Neale rate			–	.299*	–.072	.042	.007	.035	.067	.063	.056	.048	.127	.137	–.010	.084
Gates				–	.272*	.406**	.128	.302*	.279*	.164	.048	.167	.315*	.103	.087	.077
BPVS					–	.429**	.206	.441**	.070	.374**	.226	.433**	.331*	.312*	–.019	.256*
VIQ						–	.180	.457**	–.002	.349**	.266*	.286*	.526**	.406**	–.010	.121
PIQ							–	.246	.190	.118	.090	.363**	.264*	.045	.087	.192
TROG								–	.134	.368**	.116	.490**	.432**	.393**	.161	.279*
Deletion									–	.217	.113	.114	.039	.054	.245	.276*
Odd-one-out										–	.310*	.350**	.330*	.443**	.154	.248
Integration											–	.169	.214	.235	.010	.044
Monitoring												–	.365**	.389**	.018	.274*
Structure													–	.390**	–.008	.226
Titles														–	.102	.314*
WM digit															–	.360**
WM verbal																–

* Correlation is significant at the .01 level (2-tailed). ** Correlation is significant at ≤ .001 level (2-tailed).

TABLE 4
Correlations between variables at Time 1

	Neale acc.	*Neale comp.*	*Neale rate*	*Gates*	*BPVS*	*TROG*	*Del.*	*Odd-one-out*	*Inference*	*Liter.*	*Moni-toring*	*Ana-gram*	*Titles*	*WM verbal*	*WM digit*	*Maths*
Age	−.010	.040	−.015	−.061	−.018	.012	−.002	.063	.013	.030	−.052	−.016	−.109	−.005	.031	.051
Neale accuracy	–	.407**	.387**	.570**	.389**	.339*	.415*	−.027	.050	.003	.245	.274*	.132	.321*	.132	.203
Neale comprehension		–	.226	.541**	.629**	.522**	.198	.338*	.521**	.272*	.490**	.344*	.449**	.498**	.344*	.232
Neale rate			–	–	.273*	.056	.196	−.024	−.097	.116	.148	.156	.167	.040	.185	.060
Gates				–	.645**	.497**	.402**	.190	.322*	.130	.408**	.425**	.328*	.421**	.170	.258
BPVS					–	.402**	.277*	.245	.447**	.221	.399**	.231	.373**	.508**	.220	.261
TROG						–	.255	.247	.357**	.300*	.407**	.386**	.367**	.420**	.274*	.361**
Deletion							–	.262	.159	−.003	.217	.255	.230	.200	.301*	.263
Odd-one-out								–	.248	.289*	.359**	.195	.451**	.324*	.281	.320*
Inference									–	.321*	.272*	.250	.398**	.417**	.240	.239
Literal										–	.055	.070	.175	.180	.208	.254
Monitoring											–	.312*	.486**	.426**	.195	.291*
Structure												–	.289*	.350*	.206	.092
Titles													–	.309*	.181	.210
WM verbal														–	.313*	.383**
WM digit															–	.429**
Maths																–

** Correlation is significant at the .01 level (2-tailed). * Correlation is significant at the .05 level (2-tailed).

with all of the experimental measures of comprehension subskills at each time point. In addition, it was correlated with the measure of verbal working memory, digit working memory (Time 2 only) BPVS, Gates-MacGinitie sight vocabulary (Time 2 only), TROG, verbal IQ, and with one of the phonological awareness tasks (the odd-one-out task). By contrast, Neale accuracy at Time 1 was strongly correlated with Neale reading rate, Gates-MacGinitie sight vocabulary, and the phoneme deletion task, but no other measures. At Time 2, both Neale accuracy and comprehension were correlated with one of the experimental measures of comprehension subskills, the story anagram task, and also the verbal working memory task. Of the other measures at Time 2, BPVS, Gates-MacGinitie vocabulary, and TROG were also related both to Neale Accuracy and to Neale Comprehension.

One notable difference in the pattern of correlations at Time 1 and Time 2 was the finding that the subcomponents of the Neale analysis (Accuracy and Comprehension) were significantly correlated at Time 2, but not at Time 1. Perhaps it was because of this increased shared variance between the two components of the Neale Analysis that more variables were correlated with each of the two components at Time 2. Because the two components of the Neale test were correlated at Time 2, we calculated the correlations between the other variables and Neale Comprehension with Neale Accuracy partialed out. This partialing made little difference to the pattern of correlations with Neale Comprehension: all of the measures that were correlated with comprehension remained so even when Neale Accuracy was taken into account.

We also calculated the intercorrelations between the measures used to assess each skill at the two different time points. These intercorrelations are reported in Table 5. As can be seen from Table 5, almost all of the measures were significantly correlated at the two time points. The one exception was the assessment of integration and inference skills. We discuss this finding in more detail in the summary and discussion section.

Multiple regression analyses

The data were then subjected to two sets of multiple regression analyses for each time point: one with Neale Accuracy, and one with Neale Comprehension as the dependent variable. At the first four steps, a number of "control" variables were entered. These were factors that we thought might contribute to comprehension skill: age, verbal IQ, performance IQ, and vocabulary (BPVS). At Time 2, the IQ measures were those taken at Time 1, as IQ was not measured in this wave of testing.

TABLE 5
Inter-correlations between different versions of each test at Time 1 and Time 2

Variable	*Correlation*	*N*	*Comments*
Accuracy	.633, $p < .001$	96	
Comprehension	.690, $p < .001$	96	
Rate	.360, $p < .001$	96	
Gates	.486, $p < .001$	96	
BPVS	.546, $p < .001$	92	
TROG	.583, $p < .001$	92	Syntax (TROG)
Deletion	.584, $p < .001$	92	
Odd-one-out	.607, $p < .001$	92	
Integration/inferences	.046, ns	92	Integration T1/inferences T2
Integration/literal	.256, $p < .01$	92	Integration T1/literal T2
Monitoring	.476, $p < .001$	92	Sum of inconsistent and consistent
Anagram	.338, $p < .01$	91	
Titles	.268, $p < .01$	91	
Working memory digit	.255, $p < .01$	91	
Working memory verbal	.326, $p < .01$	92	

Note: All tests are one-tailed.

A summary of the multiple regression with reading comprehension as the dependent variable at Times 1 and 2 is shown in Table 6. At each time point, PIQ was marginally predictive of reading comprehension if entered before verbal IQ and BPVS vocabulary, and both verbal IQ and BPVS vocabulary accounted for significant independent variance in comprehension skill. At the fifth step we entered, each in turn, the other variables of interest.[3]

As can be seen from Table 6, at each time point a number of experimental measures accounted for independent variance in Neale comprehension scores, even after vocabulary, age, and IQ had been entered into the regression equation. At Time 1, these measures were: comprehension monitoring, the two story structures measures (explaining the function of a title, and the story anagram task), performance on the constructive inference task, verbal working memory, and one of the phonological awareness tasks (the ‘‘odd-one-out’’ task). It should be noted that a very similar pattern emerged when Gates-MacGinitie sight vocabulary was entered after age. The variables that account for variance in Neale Comprehension at Time 2 were, broadly, similar to those

[3] We did not, in the analyses reported, control for Neale Accuracy since it is obviously not possible to include this control in the second set of analyses: in which Neale Accuracy is the dependent variable. However, regression analyses in which Neale Accuracy was partialled before the specific predictors of comprehension skill were entered into the regression equation showed an identical pattern of results.

TABLE 6
Summary of regressions with Neale comprehension as criterion

		Time 1 (N = 102)		*Time 2 (N = 92)*	
Step	*Variables*	*R-square change*	*Significance level*	*R-square change*	*Significance level*
1	Age	.010	ns	.000	ns
2	PIQ	.034	$p < .07$	.017	ns
3	VIQ	.150	$p < .001$	.238	$p < .001$
4	BPVS	.072	$p < .003$	.171	$p < .001$
5	Accuracy	.002	ns	.016	ns
5	Gates	.001	ns	.010	ns
5	Rate	.017	ns	.020	ns
5	TROG	.018	ns	.001	ns
5	Deletion	.000	ns	.001	ns
5	Odd-one-out	.115	$p < .001$	.066	$p < .03$
5	Integration/inference (1)	.077	$p < .001$	.066	$p = .001$
5	Literal memory (2)	n/a	n/a	.019	ns
5	Monitoring	.094 (3)	$p < .001$	.068	$p < .002$
5	Anagram	.028 (4)	$p = .056$	.023	$p = .06$
5	Titles	.150	$p < .001$	.044	$p < .01$
5	WM digit	.004 (5)	ns	.029	$p < .04$
5	WM verbal	.068	$p < .002$	.036	$p < .02$
5	Maths	n/a	n/a	.002 (6)	ns

Notes for comprehension analyses.
(1) Integration scores at Time 1; sum total of inter-sentence and contextual/gap-filling inferences at Time 2.
(2) Time 2 only.
(3) Total scores for consistent and inconsistent stories.
(4) Missing data at time one, N = 101. Total variance from steps 1–4 = .260.
(5) Missing data, N = 101. Total variance from steps 1–4 = .266.
(6) Missing data, N = 94. Total variance from steps 1–4 = .425.

observed at Time 1. Rather than detailing all the similarities between the two sets of results, we highlight the differences. The most marked difference was that, at Time 2, the measure of syntactic skills (TROG) accounted for significant variance in Neale Comprehension. A more minor change was that both working memory measures (not just the verbal measure) accounted for variance in Neale Comprehension at Time 2. The story anagram task was still only marginally predictive of Neale Comprehension.

Our changes to the literal and inferential memory task made a difference to the pattern of results and enabled us to discriminate the separate contributions of literal memory and inference skills. At Time 2, the inference component was strongly related to Neale Comprehension, but the ability to answer literal questions was not. The only completely new measure at this time—mathematical ability—was not linked to reading comprehension once IQ had been taken into account.

The results when Neale Accuracy was treated as the criterion variable are reported in Table 7. These contrasted sharply with those when comprehension was the criterion variable. The same ‘‘control’’ variables were entered first: age, verbal IQ, performance IQ, and vocabulary (BPVS). As before, different measures were entered in turn at the fifth step. The pattern of results from the multiple regression analysis is shown in Table 6. As can be seen, at the first four steps only verbal IQ accounted for significant variance in Neale accuracy at Time 1. BPVS vocabulary was not a significant predictor, at least when entered after verbal IQ, but that is not surprising given that one of the verbal IQ subtests is an assessment of

TABLE 7
Summary of regression analyses with Neale reading accuracy as criterion

		Time 1 (N = 102)		*Time 2 (N = 92)*	
Step	*Variables*	*R-square change*	*Significance level*	*R-square change*	*Significance level*
1	Age	.000	ns	.003	ns
2	PIQ	.017	ns	.002	ns
3	VIQ	.047	$p < .03$	.176	$p < .001$
4	BPVS	.000	ns	.034	$p < .06$
5	Gates	.418	$p < .001$	.131	$p < .001$
5	Rate	.257	$p < .001$	.067	$p < .006$
5	TROG	.002	ns	.021	ns
5	Deletion	.127	$p < .001$	.112	$p < .001$
5	Odd-one-out	.001	ns	.015	ns
5	Integration/inference (1)	.007	ns	.023	ns
5	Literal (2)	–	–	.007	ns
5	Monitoring (3)	.000	ns	.009	ns
5	Anagram	.007 (4)	ns	.013	ns
5	Titles	.002	ns	.003	ns
5	WM digit	.013 (5)	ns	.000	ns
5	WM verbal	.001	ns	.016	ns
5	Maths	n/a	n/a	.006 (6)	ns

Notes for accuracy analyses.

(1) Integration scores at Time 1; sum total of inter-sentence and contextual/gap-filling inferences at Time 2.

(2) Time 2 only.

(3) Total scores for consistent and inconsistent stories.

(4) Missing data, N = 101. Total variance from steps 1–4 = .062.

(5) Missing data, N = 101. Total variance from steps 1–4 = .064.

(6) Missing data, N = 94. Total variance from steps 1–4 = .214.

Job No. 9730 Mendip Communications Ltd Page: 461 of 468 Date: 18/7/03 Time: 7:35am Job ID: LANGUAGE 006949

productive vocabulary, and the ‘‘similarities’’ subtest is ‘‘vocabulary loaded’’.

At each time point only three measures predicted variance in Neale accuracy once vocabulary and IQ had been entered into the regression equation. Those were: Neale reading rate, Gates vocabulary (another measure of word recognition), and one of the phonological awareness tasks (phoneme deletion).

SUMMARY AND DISCUSSION OF FINDINGS

The pattern of results from the regression analyses was largely as we had predicted: verbal IQ and vocabulary accounted for variance in Neale Comprehension but, over and above these measures of general verbal ability, most of the subskills that we expected to be related to comprehension skill were significant: comprehension monitoring, text integration skill, and the two measures of story structure knowledge accounted for variance in Neale Comprehension, but not Neale Accuracy. We discuss the unpredicted findings in more detail below.

Perhaps the most puzzling relation we found was that between Neale Comprehension and the ‘‘odd-one-out’’ task. Clearly, this result was not in line with our predictions at the outset of this study: we had expected that the two phonological awareness tasks would be related to Neale Accuracy, but had not expected them to be related to Neale Comprehension. However, since starting the longitudinal study, we have found a relation between the odd-one-out task and the Neale Comprehension in other, cross-sectional studies (Cain, Oakhill, & Bryant, 2000), though we have yet to find any other test of phonological awareness that is related to comprehension (see, also, Stothard & Hulme, 1996). We hypothesized that the relation we observed may have been mediated by working memory. We have shown previously that reading comprehension is related to measures of working memory in children of primary school age (see Seigneuric, Ehrlich, Oakhill, & Yuill, 2000; Yuill, Oakhill, & Parkin, 1989) and we have recently demonstrated that verbal working memory is significantly related—over and above age and reading ability—to performance on the odd-one-out task, but not on another measure of phonological awareness (phoneme deletion) (Oakhill & Kyle, 1999). Thus, it is plausible that the link between performance on the odd-one-out task and Neale Comprehension is mediated, at least in part, by working memory.

Another finding that requires further discussion is the pattern of relation between TROG and both Neale Comprehension and Accuracy. We did not have any strong predictions about the TROG but would have expected that, if anything, it would be more closely related to Neale Comprehension than Neale Accuracy at both time points. TROG was correlated with both measures of reading at Time 2 but not at Time 1, but it did not account for variance in comprehension skill at Time 1 once a number of other measures had been taken into account. Based on Tunmer's (1989) findings, we might have expected to find a stronger relation between Neale Comprehension and the test of syntactic knowledge (TROG). Two points should be considered. First, the tasks used to assess syntactic processing in the two studies are very different: Tunmer used a sentence anagram task to measure syntactic awareness, whereas we used a task that demands knowledge of specific syntactic structures. Second, it is possible that the items that discriminate between readers in the older age group are ones with a high processing component, such as embedded relative clauses. So perhaps performance on the TROG at that level is more closely related to individual differences in working memory, which we already know is linked to comprehension skill. Indeed, the patterns of correlation show a much higher correlation between TROG and verbal working memory, in particular, at Time 2 (.42) than at Time 1 (.28).

The third finding that warrants discussion is the lack of a correlation between our assessments of integration and inference skills. We used two different measures of this ability at the two times (for the reasons given earlier). At Time 1, the measure was one of text "integration" (i.e., the ability to remember the content, rather than the precise wording of short texts). At Time 2, the measure comprised an assessment of both text-based (bridging) inferences, and inferences based on general knowledge. However, even though the measures of inference and integration at Times 1 and 2 were not significantly intercorrelated, as we had expected, both were highly correlated with comprehension skill. It seems that the two forms of assessment are tapping into different aspects of comprehension ability. This possibility is supported by the finding of a small, but significant, correlation between the Time 1 integration measure, and the ability to answer literal questions at Time 2. This relation suggests that the Time 1 integration measure was more dependent on memory for the wording of the text than we had expected. The hypothesis that the tasks are tapping into related but distinct processes also concurs with recent findings from Hannon and Daneman (2001). Those authors found that distinctly different components of a complex working memory task were related to their "short stories task" (precisely the task we used at Time 1) and a bridging inference task (which has considerable similarity to the inference task we used at Time 2).

Finally, it is puzzling that the story anagram task was not more highly related to reading comprehension skill in the regression analyses, but this is perhaps because it shares variance with IQ. Indeed, the first-order correlation between the story anagram task and verbal IQ (measured at

Time 1) was considerably higher than that between either inference and VIQ or comprehension monitoring and VIQ.

In summary, despite a few unexpected findings, our main predictions were confirmed. The most striking finding in this set of analyses is that, at both time points, not a single experimental measure accounted for variance in both Neale Comprehension and Neale Accuracy once the variance associated with verbal ability had been accounted for. Thus, we have shown that distinctly different skills and abilities account for variance in reading comprehension skill and in word reading ability.

GENERAL DISCUSSION

These data provide clear evidence that, although word reading and comprehension skill are correlated, distinctly different abilities account for variance in these reading subskills. Comprehension skill was related to many of the skills that we have previously found to differentiate between skilled and less-skilled comprehenders: text integration, knowledge about story structure, metacognitive monitoring, and working memory. By contrast, these measures did not account for variance in single-word reading accuracy, which was best accounted for by a phoneme deletion task. The only measure that accounted for variance in both reading accuracy and comprehension (at Time 2 only) was the TROG.

Furthermore, it is interesting to note that these abilities account for variance in reading comprehension and reading accuracy, even after the variance accounted for by general ability (IQ) and more general language skills (such as vocabulary) has been entered into the regression equation. Thus, although IQ—verbal IQ in particular—is quite strongly related to comprehension skill, other skills and abilities are important, over and above IQ. This finding has important implications. If less-skilled comprehenders are simply low-verbal, then an obvious remediation recommendation would be to train them in vocabulary, but such training is known to be fraught with difficulties (Beck & McKeown, 1991). However, two points can be made in relation to this point. First, vocabulary per se may not be the issue but, rather, the richness of a child's semantic representations: individuals who possess a rich and interconnected knowledge base may comprehend text better than those whose representations are sparse. For example, Spilich, Vesonder, Chiesi, and Voss (1979) demonstrated that prior knowledge about the topic of a text facilitates reading comprehension. Thus, if word meanings are poorly represented in semantic memory, less information will be accessed and perhaps fewer relations between concepts will be made than if a rich semantic representation for word meaning exists. Indeed, in two recent papers, Nation and Snowling (1998, 1999) report differences between good and poor comprehenders on measures of semantic fluency and semantic priming, and conclude that semantic weaknesses underlie comprehension difficulties. Second, it should not be assumed that that (higher) intelligence or vocabulary *causes* good comprehension (or, at least, permits the development of comprehension skills, given an appropriate environment). It is equally possible that good comprehension (which is likely to be associated with extensive and wide reading) may be causally linked to performance on IQ tests. Indeed, there is now some evidence for a link in this direction. For instance, Stanovich (1993)—in a provocatively named chapter, *Does Reading Make You Smarter?*—showed that reading experience (''exposure to print'') can facilitate growth in general verbal ability as well as increasing performance on non-verbal IQ assessments (Raven's Matrices). In addition, Pretorius (2000) argues that it is precisely the inference skills that underpin reading comprehension more generally that are fundamental to the ability to learn new vocabulary (because word meanings must be inferred from context). However, if as we have shown, there are specific skills that contribute to reading comprehension over and above general verbal ability and vocabulary skills, these skills would be likely candidates for training.

In general, our results are consistent with those in the literature in showing that word reading and comprehension skills can be clearly differentiated. These findings fit with observations from clinical populations. For instance, the phenomenon of hyperlexia also suggests that decoding and comprehension can develop relatively independently. Hyperlexic children have unexpectedly precocious single-word reading, but poor comprehension. The converse pattern can, of course, be seen in dyslexia. Aaron, Frantz, and Manges (1990), for example, used a double-dissociation paradigm to show that pronunciation and comprehension skills are dissociable and have independent effects on reading performance. However, we have gone further in showing that not only are the two subcomponents of reading ability separable, but that distinctly different skills and abilities account for variance in those subcomponents. In contrast, a recent study by Shankweiler et al. (1999) appears to come to rather different conclusions. In a large sample of 7 to 9-year-olds, those authors found that differences in reading comprehension were closely associated with differences in decoding skill. This, in itself, is not inconsistent with our own findings, but what is inconsistent is the relative absence of children who showed a discrepancy (in either direction) between their decoding and comprehension skills. However, Shankweiler et al.'s subjects were recruited in response to a call for children with learning difficulties, and only 51 out of the sample of 361 were normal controls without reading or learning problems. In their group of subjects, therefore, poor word readers predominated. Thus, it is not surprising that

Shankweiler et al. found few children who showed poorer comprehension than word reading, since reading levels were generally well below average. The major difference between their population and ours (we specifically excluded poor word readers) could account for the different contribution of phonological skills to reading problems. This observation raises broader methodological issues, and underlines the need to consider the composition and characteristics of groups of participants when exploring skill dissociations.

Our results have more general implications for the reaching of reading and for the remediation of reading problems. One important implication is that, because the two components of reading seem to be showing different developmental trajectories, and are underpinned by different skills, it is likely that they need to be taught (at least to some extent) independently. Certainly, one cannot assume that if the skills that underpin efficient word decoding are taught, that comprehension will naturally follow. A second important implication is that children's reading problems need to be properly diagnosed to determine which of the components of reading they are lacking. A child who fails a reading test in which they are required to read a passage and answer questions, may have problems because they have difficulties with single-word reading, with comprehension, or with both. Since the remediation procedures for poor reading or for poor comprehension are very different in kind, one needs to know which skill is lacking before effective remediation procedures can be implemented.

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