BERJ | Research Journal
BERA BRITISH EDUCATIONAL RESEARCH ASSOCIATION

British Educational Research Journal
Vol. ●●, No. ●●, ●● 2014, pp. ●●–●●

DOI: 10.1002/berj.3134

Local text cohesion, reading ability and individual science aspirations: key factors influencing comprehension in science classes

Sophie S. Hall[a,*], Rebecca Kowalski[a], Kevin B. Paterson[a], Jaskaran Basran[a], Ruth Filik[b] and John Maltby[a]
[a]*University of Leicester, UK;* [b]*University of Nottingham, UK*

In response to the concern of the need to improve the scientific skills of school children, this study investigated the influence of text design (in terms of text cohesion) and individual differences, with the aim of identifying pathways to improving science education in early secondary school (Key Stage 3). One hundred and four secondary school children (56 females, 48 males), aged 12–13 years took part in the study. To assess the influence of local cohesion (lexical and grammatical links between adjacent sentences) in science texts, we measured students' comprehension (through multiple choice questions) of science text that was high and low in local cohesion. To explore the role of individual differences, students completed tests to measure general reading ability, general intelligence, facets of conscientiousness, science self-concept and individual, friends and family aspirations in science. Students were more accurate in answering comprehension questions after reading text that was high in cohesion than low in cohesion, suggesting that high local text cohesion improved students' comprehension of science text. Reading ability predicted increased comprehension for both text designs. Individual aspirations in science accounted for unique variance for comprehension for high cohesion text. Implications for the teaching of secondary school science are discussed.

Introduction

There is growing recognition of the crucial role of developing scientific literacy to improve science education and in encouraging young people to study science to an advanced level (e.g., Norris & Phillips, 2003). Student interest in science declines from approximately 11 years of age (the start of secondary education; Key Stage 3), with one of the main causal factors being the quality of the educational experience (Osborne *et al.*, 2003). Given that students spend two-thirds of their lives outside of formal schooling there is also increasing awareness of the need to understand the contributions of the attitudes and involvement of family and friends in determining an individual's interest and achievement in science (Gilbert, 2006). With the aim of developing pathways to improving science achievement in secondary schools, we investigated beginning secondary school students' comprehension of science text in a classroom exercise by focussing on two key issues: (1) the influence of text design; (2)

*Corresponding author. University of Leicester, Henry Wellcome Building, School of Psychology, Lancaster Road, Leicester, LE1 9HN, UK. Email: sophie.hall@dmu.ac.uk

the role of individual differences, including beliefs and attitudes. More specifically, we examined the role of local text cohesion in text designs. Local text cohesion can be defined as the presence (high cohesion) or absence (low cohesion) of lexical and grammatical cues which enable the reader to link meanings across adjacent sentences.

Comprehension of science text

Successful comprehension relies on fundamental reading skills such as letter identification and accessing word meaning (Perfetti, 1985), and the integration of individual word meanings into a coherent representation of the sentence (local text cohesion) (Vellutino *et al*., 1994). The ability to integrate sentences promotes the development of a coherent text representation necessary for sound comprehension (Kintsch, 1998). As such, the ability to integrate the meanings between sentences in science text is likely to be important for successful comprehension, and therefore science learning. Accordingly, we chose to explore the effects of local text cohesion in determining science comprehension.

Text cohesion refers to the extent to which the text supports the reader in establishing a coherent understanding of the text. In high cohesion text, the text itself is usually sufficient for the reader to obtain a coherent representation of the arguments. By comparison, low cohesion text requires the reader to generate inferences that go beyond the information provided in the text in order to achieve a coherent representation of the meaning of the text (see McNamara *et al*., 2010). Our rationale for focussing on text cohesion derives from analyses showing that science textbooks are frequently low in text cohesion, with regular omissions of information that may be crucial for achieving accurate comprehension (Beck *et al*., 1991). Such information includes the use of linguistic devices which provide explicit links between sentences. For example, studies have shown that text comprehension can be improved by adding cohesive ties, including elaborating on concepts, replacing ambiguous pronouns with nouns, and adding connectives ('and', 'because') (see, e.g., Beck *et al*., 1991; Ozuru *et al*., 2009).

Modulations of text cohesion can be further illustrated by examining the text used by Ozuru *et al*. (2009) in an extract 'Heat Distribution in Animals'. For instance, they repeated the terminology 'warm blooded animals' in high cohesion text, but used 'them' (pronouns) and 'mammals' (ambiguous noun) to refer to these animals in low cohesion text. The authors used 'because' (connective tie) in high cohesion texts to explain why some warm-blooded animal allow their body temperature to drop, whereas in low cohesion text they just stated the facts without a causal connection. Additionally, they elaborated on concepts in high cohesion text (e.g., by stating that blood vessels are part of the animals circulatory system) but not in low cohesion text. The use of extra connectives and elaborating on concepts produces a longer text when it is a high cohesion design compared to a low cohesion design. Furthermore, by avoiding the use of pronouns, high cohesion text typically contains a greater degree of repetition than low cohesion text.

When links between sentences are not explicit (low cohesion design), the reader has to infer the relationships between different linguistic expressions (e.g., that 'them' refers to 'warm blooded animals') and this can cause comprehension difficulty

(Graesser *et al.*, 2003). In these situations the reader must dedicate more processing effort in order to comprehend the text, relying on activating memory traces relating to the previously read text sections as well as reasoning activities (Long & Lea, 2005; Kintsch, 2009), and so impairing comprehension. Increasing text cohesion has beneficial effects on adults' comprehension of both narrative (e.g., Beck *et al.*, 1984) and expository texts (e.g., Linderholm *et al.*, 2000). The effects of text cohesion on comprehension is typically assessed through the use of multiple choice questions (MCQs) or short answer questions (e.g., Ozuru *et al.*, 2009, 2010; McNamara *et al.*, 2011). These measures allow the researcher to directly explore specific aspects of comprehension (e.g., the links made between two sentences) which may not be possible with open-ended style comprehension questions.

More recently, investigations have begun to look at text cohesion in college-aged students' science text comprehension and found similar increases in comprehension with greater text cohesion (Ozuru *et al.*, 2009). However, only a few studies have looked at text cohesion with younger school students (Best *et al.*, 2006; McNamara *et al.*, 2011) and these reports suggest that text cohesion does not significantly improve science comprehension at this age. Both of these two studies used an age range of 9–11 years, focussing on children at the end of primary school (Key Stage 2), rather than the start of secondary education (Key Stage 3), leaving this latter age-group surprisingly under-investigated.

In summary, the cohesive structure of text designs appears to play an important role in determining levels of comprehension. These effects have primarily been investigated in older school students, but may also be important factors for determining comprehension in young secondary school students. Additionally, in secondary school education other factors should be considered in relation to science learning, including individual differences which have been identified, as modulating text comprehension and achievement.

The role of individual differences

Previous research suggests that a number of individual differences variables, focussing on levels of literacy, intelligence, personality and social influences, relate to an individual's capacity and aptitude for science learning (e.g., St George *et al.*, 1997; Chamorro-Premuzic & Furnham, 2003; Primor *et al.*, 2011). Examining these individual differences variables in relation to the comprehension of texts with varying levels of cohesion could provide valuable insights into specific approaches that may be central to promoting science text comprehension and therefore better science achievement.

Individual reading ability is an important factor in determining text comprehension (Just & Carpenter, 1992; St George *et al.*, 1997). Reading skills, including word decoding and vocabulary have been shown to be strong predictors of comprehension (Schatschneider *et al.*, 2007), with some children who have difficulties in reading comprehension showing poor vocabulary skills (Catts *et al.*, 2006). Reading skills help readers to relate concepts from different parts of the text via inferential processes (Daneman & Hannon, 2001). By relating these disparate concepts, readers can form a cohesive representation of the text, and so this suggests an important relationship between reading skill, text cohesion and subsequent comprehension. Whilst poor reading ability reduces comprehension (Cain & Oakhill, 2004), the interaction between reading skill and text cohesion in influencing comprehension of text is not linear. For instance, only skilled readers are thought to benefit from reading high cohesive texts (O'Reilly & McNamara, 2007; Ozuru *et al.*, 2009). It has been suggested that this reflects the increased density and complexity of reading text which is highly cohesive (Beck *et al.*, 1991; Ozuru *et al.*, 2009). It is clear that to date, the relationship between reading ability and text cohesion is not well established, especially as reading ability can be determined by a large variety of skills, including word decoding (Perfetti, 1985), syntactic knowledge and inferential abilities (Oakhill & Yuill, 1996).

There is conflicting evidence as to the importance of general intelligence in mediating reading comprehension. Oakhill *et al.* (2003) report that although IQ (a measure of general intelligence), is related to comprehension abilities, other skills are more significant, including the ability to integrate text, metacognitive monitoring and working memory. Additionally, children with lower IQ scores do not have reliably lower scores of reading ability; likewise, children with higher IQ do not consistently achieve higher scores on reading ability tests (Meyer, 2000). More recently, research has investigated whether general intelligence interacts in a similar manner with the comprehension of narrative and expository text. Primor *et al.* (2011) reported that scores on Ravens Matrices predicted comprehension on both text-types for participants with reading disabilities; however, scores on Ravens Matrices only predicted comprehension of *narrative* texts for participants without reading disabilities. Whilst this study was conducted with Hebrew speaking adult readers, similar effects have been reported with English speaking children (Tiu *et al.*, 2003).

Studies have also shown a relationship between personality and academic achievement. Personality traits of openness to experience and conscientiousness are significantly related to academic achievement (Robinson *et al.*, 1994; Chamorro-Premuzic and Furnham, 2003), with conscientiousness reported as the strongest personality predictor of college students' grades (Matthews *et al.*, 2006; Noftle & Robins, 2007). More specifically, conscientiousness has been shown to be strongly related to science achievement (Eilam *et al.*, 2009) and interest (Fesit, 2012). However, a recent review highlights inconsistencies within the research examining personality and reading comprehension and appeals for more research to examine the potential relationships between these factors (Sadeghi *et al.*, 2012).

It is well documented that academic achievement is modulated by individual beliefs and interests (Valentine *et al.*, 2004; DiPerna, 2006; Rothon *et al.*, 2011) as well as influences from parents and peers (Duncan *et al.*, 2001; Nichols & White, 2001; Gonzalez-DeHass *et al.*, 2005; Seginer, 2006; Rogers *et al.*, 2009). Individual beliefs that are likely to be important in determining science achievement include self-concept and career aspirations. Academic self-concept is highly domain-specific (Marsh & Hau, 2004; Möller *et al.*, 2009); science self-concept refers to an individual's belief in their abilities in science alone. Both positive (Wilkins *et al.*, 2002) and negative (Kifer, 2002) relationships have been reported with science self-concept and achievement, indicating that the role of domain-specific self-concepts and subsequent achievements require further investigation. Some research suggests that career aspirations modulate academic achievement (e.g., Benbow *et al.*, 1991). Career interest for science occupations has been shown to develop particularly early in secondary education (Foskett & Hemsley-Brown, 2001), providing motivation for investigating the role of science aspirations on science comprehension and achievement. With regard to influences from external sources, including parents and peers, a recent study reported that students who reported positive attitudes to scientific studies were those who also experienced support from significant others in their lives (Aschbacher *et al.*, 2010), demonstrating an important interaction of support and attitudes that requires further investigation. Additionally, the finding that students often report negative experiences of school science is an increasing cause for concern (Osborne & Collins, 2001; Osborne *et al.*, 2003), which may prove to have a mediating role in science achievement.

Aims of the study

It is evident that text cohesion may play an important role in determining the comprehension of scientific text, and that, when considering how students learn in school, it is important to consider a range of individual differences. However, two key issues remain to be addressed. Firstly, how do local text cohesion and academic individual differences interact with young students' comprehension of science text? Secondly, in order to develop effective science teaching strategies we need to understand which of these variables are of particular importance for predicting science text comprehension in the classroom.

To address these questions we investigated the influence of different text cohesion designs (high and low) on determining secondary school students' comprehension of science text in a classroom exercise. It was predicted that if a locally cohesive text design enhanced students' understanding of textbook science, this would be observed in greater accuracy in responding to MCQs after reading text that was high in local cohesion compared to low in local cohesion. With the aim of identifying factors which may prove important in promoting scientific attainment, we investigated the predictive role of individual differences that have been identified as being particularly relevant to science text comprehension at secondary school age. The individual differences measured were: reading ability, general intelligence, conscientiousness, self-concept in science, science aspirations, experience of school science, parental support and involvement, and peer orientation to school and science.

Method

Participants

104 participants (56 female, 48 male) from a mixed ability secondary school in Leicestershire, UK, took part in the study. Participants were of mixed ethnic origin, and ages ranged from 12–13 years (12.3 years ± 2.1; Mean ± Standard Error). Participants were instructed that the study was investigating the design of science text

books. Parental consent was obtained for all participants. Testing procedures complied with BPS Ethics Code of Conduct (2009).

Materials

Text. To assess the influence of text designs (low vs. high cohesion) on comprehension ability we presented students with four extracts from science textbooks that were manipulated in terms of local cohesion (high and low cohesion). The texts were taken from secondary school science textbooks (*Catalyst: A framework for success*; Chapman & Sheehan 2003) on four separate topics so that experience of reading one text should not influence the readers' understanding of another text. The four topics were photosynthesis, transport of water and minerals, changes of state, and seasonal changes. The texts were presented in a pseudo-random order across the student group (so that each text was presented in first, second, third and fourth position). Based upon previous research (Ozuru *et al.*, 2009), cohesion was increased through: (1) adding connectives (2) reducing the use of ambiguous nouns and (3) elaborating on unfamiliar concepts. For example, in Figure 1 evidence of elaborating concepts include *line 1*, where it is made clear that the solids are made up of heated particles, *line 2*, where it is specified that the particles are closely packed in a solid, *line 3*, which states that heat makes the particles move faster. Examples of reduced use of ambiguous nouns are on *line 2*, 'the closely packed particles within the solid', *line 4*, 'if the substance/liquid', and on *line 5*, 'this transformation'. Connective devices are found on *line 3*, *line 4* and *line 5.* The key changes have been underlined in Figure 1.

All students read two high cohesion texts and two low cohesion texts. Individual students read a text extract as high cohesion, or low cohesion; they did not view the same text extract in both conditions. The topics were counterbalanced so that all of the topics were read as high cohesion and as low cohesion across the participant sample (i.e., text one was viewed as high cohesion by half the sample and low cohesion by half the sample). The students answered three MCQs on the content of each of the four texts, creating 12 questions in total. The MCQs were composed with four answers, one of which was correct. They were designed to test the students' comprehension of each text by assessing whether the student had correctly linked the information in successive sentences (measures of local cohesion), for example, whether the student had correctly inferred a causal relationship between adjacent sentence, as determined by the presence of 'because' in the text (high cohesion) or by knowledge based inference when no connective was presented (low cohesion).

Individual differences. Students were given five tests to measure individual differences.

Reading ability (Nelson–Denny reading test). To reduce testing time and participant effort only the vocabulary component of the Nelson–Denny reading test was used to assess students' reading ability (Brown *et al.*, 1993). The students read the beginning of a sentence and were asked to choose which one of five words they felt best completed the sentence. For example, 'flexible means a) liveable b) bendable c) fixable

(a)

High cohesion text	**Low cohesion text**
When you heat a solid the particles within it start to vibrate faster.	Heated solid particles vibrate faster.
The closely packed particles within the solid start to break free from each other.	Particles start to break free from each other.
As a result of the particles breaking free the solid melts into a liquid.	Solids melt into a liquid.
If the substance / liquid is heated more the particles will move even faster until they are in random motion.	Particles move even faster until they are in random motion if liquids are heated more.
As a result the liquid will become a gas.	Liquid will become gas.
This transformation is called evaporation.	It is called evaporation.

(b)

What causes a solid to melt into a liquid?

A) The particles breaking free from one another
B) The particles being closely packed together
C) The particles being in random motion
D) Evaporation

What cause a liquid to become a gas?

A) If the particles are cooled
B) If the liquid is heated more the particles move faster to produce random motion
C) If the particles become more closely packed together
D) If the particles do not move

What is the transformation of a liquid to a gas known as?

A) Condensing
B) Freezing
C) Melting
D) Evaporation

Figure 1. Demonstration of stimuli used: (a) illustrates the difference between high and low cohesion text on a sentence-by-sentence basis; (b) shows an example of three of the multiple choice questions used to assess comprehension.

d) fragile e) fused'. The vocabulary section has been used in similar research (Ozuru *et al.*, 2009) and has high Cronbach's alpha scores of internal reliability (α =.90). Additionally, the test has been shown to be a good predictor of academic success (Hawes, 1982; Wood, 1982; Collins & Onwuegbuzie, 2002). Scores of reading ability were based on the total number of correct responses.

General intelligence. We used a measure of general intelligence derived from the Ravens Progressive Matrices (RPM) (Raven *et al.*, 1998). Each item requires the participant to infer a rule which relates the elements together, and then to use this rule to identify the next element in the sequence by choosing from eight alternatives (Alderton & Larson, 1990). Ravens matrices are straightforward to administer and have well documented reliability and validity scores (Strauss *et al.* 2006), with correlations with other intelligence test between .40 and .75 (Raven *et al.*, 1998). Recent updates to the Ravens manual state that when time is limited, as with our relatively young sample, Set 1 alone (out of a possible five sets) provides a sufficient measurement (Harcourt Assessment, 2003). Indeed, shortened versions of the RPM have been shown to have similar psychometric properties to the full test (Hammel & Schmittmann, 2006; Van der Elst *et al.*, 2011), with good Cronbach's alpha scores of internal reliability (.73; Bors & Stokes, 1998), good convergent validity scores consistent with the full item (Arthur *et al.*, 1999), and high test–retest scores (.75; Arthur *et al.*, 1999). Therefore, to reduce participant effort we gave students 10 minutes to complete Set 1 only. It is worth noting then that when using a timed condition, the measure of general intelligence is thought to reflect *intellectual efficiency*, an overall competency and ability to efficiently use ones general intelligence (Raven *et al.*, 1998). Scores of general intelligence were based on total number of correct responses.

Conscientiousness. The short five (S5) measure of personality (e.g., see Konstabel *et al.*, 2012) was constructed to measure 30 facets of the five-factor model of personality (NEO-PI-R, Costa & McCrae, 1992) for use when time is limited. As this study was primarily interested in conscientiousness only these 12 items (six positively keyed, six negatively keyed and reverse scored) were selected for use. The questions measured the six facets thought to define conscientiousness: competence (e.g., I am sensible and competent; I can find practical, quick, and effective solutions to problems), order (e.g., I am a methodical person and I love cleanliness and order; I want everything to be in its right place), dutifulness (e.g., I am a reliable person, who values ethical principles; I keep my promises and work carefully and thoroughly), achievement-striving (e.g., I know for certain what I want to accomplish and I work hard for it), self-discipline (e.g., When I have started something, I finish it despite fatigue or other distractions; I always finish my tasks on time) and deliberation (e.g., I consider things carefully before acting or deciding; I take the possible consequences of my actions into account). The statements were evaluated as to how they reflected the reader on a scale of one to five, ranging from 'very inaccurate' to 'very accurate'. The S5 has good internal consistencies for the five broad factors (average $\alpha = 0.87$) and for the facets (average $\alpha = 0.69$). The S5 has good convergent validity with other measures of the big five (average correlation with NEO and NEO-PI-R = 0.71) (Konstabel *et al.*, 2012). Scores of conscientiousness were based on totalled ratings.

Science self-concept (Academic Self-Description Questionnaire Inventory—ASDQI). The ASDQI was designed to measure secondary school students' self-perceived academic competence (Marsh, 1990a, b, 1993). From the original 14 scales only the one scale pertaining to self-concept in science was chosen for use (e.g., I get good marks in science classes; I learn things quickly in science). Six statements were evaluated on an eight-point scale as to how well it reflected the participant ('1' = *definitely false*, '8' = *definitely true*). Previously reported reliability measures for each scale are high (α = 0.88 – 0.94). Scores on science self-concept and academic achievement show good correlation (r = .70) (Marsh, 1992). Scores of science self-concept were based on total ratings.

Science aspirations—Science Aspirations and Careers Paradox. The Science Aspirations and Careers Paradox (SACP) was designed to survey the interests of school aged children in science and science related careers (DeWitt *et al.*, 2011). To minimise lengthy testing time and to focus specifically upon the research question, six constructs were selected: 'individual aspirations in science' (four items), 'experience of school science' (four items), 'parental support/involvement' (three items), and 'peer orientation to school/science' (four items). The items were rated on a five-point scale, from '1' (*strongly disagree*) to '5' (*strongly agree*). The 'peer orientation' items were reworded so that they could be answered using the five-point scale, for example, 'How many of your close friends get good marks in science' was changed to 'Many of my close friends get good marks in science'. Scores were based on total rating within each construct. Cronbach's alpha scores for the components used in this study range from α = .40 – .80, with the majority scoring over .60. Such reduced alpha scores are not considered unusual in studies measuring psychological constructs with children (Field, 2009), especially given the limited number of items per construct (DeWitt et al., 2011).

Procedure

As a classroom exercise, students completed one of the science booklets (A or B, counterbalanced across the group). No time limit was set; the average completion time was 20 minutes. Instructions were given to read the science texts carefully for comprehension. After reading the text, the students completed a word jumble task, in which they had to un-jumble a word (e.g., ospt—spot). This was designed to act as a short distracter task and took approximately three minutes to complete. The students then answered three MCQs based on the content of the text they had just read (see Figure 1b). This procedure was repeated until the four texts had been read. After the text-based part of the testing the participants were given the psychometric measures to complete with no time limit. Following this the Nelson–Denny reading test was administered with a 15 minute time restriction and the Ravens matrices test, with a five-minute time restriction. The testing time (maximum 50 minutes) and work required by the students was comparable to a typical classroom lesson.

Results

Text cohesion

In order to assess whether comprehension performance differed between the high and low cohesion texts, a paired-samples t-test was conducted to compare MCQ accuracy between these two conditions. A significant difference in MCQ accuracy (t (103) = 2.17, p < .05, d =.2) between high cohesion text (62.66% ± 2.24) and low cohesion text (56.57% ± 2.51) suggests that high cohesion text facilitates students' comprehension of science text. Additionally, these values suggest that the text structures and comprehension questions were suitably designed to ensure that there was variance across the conditions and participants whilst neither floor nor ceiling effects were obtained.

Individual differences

Cronbach's alphas and independent samples t-tests were carried out in order to determine that the scales had adequate internal reliability and to assess any gender differences in scores on the psychometric measures (see Table 1). All scales showed adequate internal reliability (α =.70 or above; Kline, 1986). The independent samples t-tests revealed no significant differences between males and females on their scoring on the individual difference test and on their comprehension of high/low cohesion texts (see Table 1 for t and p values).

Interaction of individual differences and text cohesion

The second stage of analysis investigated whether individual differences affected comprehension of science text. Initial analysis used a Pearson's product moment correlation to assess whether there was a correlation between the psychometric measures and accuracy in MCQs for high and low cohesion text.

As illustrated in Table 2, MCQ performance on high cohesion text was positively correlated with scores on the Nelson–Denny reading tests, Ravens matrices, self-concept in science, aspirations in science, and experience of school science. MCQ performance on low cohesion text was positively correlated with the same scales as high cohesion text, as well as two additional scales: parental support and involvement, and peer orientation to school and science.

A two-step Hierarchical Multiple Regression was performed to examine whether the individual difference variables predicted correct responses with low and high

Table 1. Mean scores and alpha coefficients for male and female students on the scales

			Males		Females			
		α	M	SD	M	SD	t	p
1	High cohesion text	---	3.85	1.30	3.67	1.42	–.65	.52
2	Low cohesion text	---	3.54	1.30	3.26	1.56	–.91	.37
3	Reading ability	.89	31.47	12.83	29.91	10.85	–.68	.50
4	General intelligence	.70	7.47	2.33	7.48	2.20	.01	.99
5	Conscientiousness	.82	40.65	7.69	41.52	6.91	.61	.54
6	Science self-concept	.74	27.73	6.89	25.73	7.29	–1.17	.24
7	Aspirations in science	.87	11.04	3.64	10.35	3.65	–.95	.34
8	Experience of school science	.85	11.91	4.08	11.39	3.59	–.69	.49
9	Parental support & involvement	.81	12.37	2.38	12.51	2.37	.31	.72
10	Peer orientation to school & science	.76	13.10	2.46	13.82	2.69	1.41	.16

Table 2. Pearson correlational data for the

		1	2	3	4	5	6	7	8	9	10
1	High cohesion text	1	.309**	.484**	.248*	.025	.305**	.367**	.211*	.076	.142
2	Low cohesion text		1	.362**	.255*	.138	.263**	.212*	.242*	.207*	.201*
3	Reading ability			1	.371**	.070	.339**	.304**	.220*	.340**	.124
4	General intelligence				1	.010	.226*	.103	.122	.208*	.087
5	Conscientiousness					1	.293**	.241*	.392**	.357**	.216*
6	Science self-concept						1	.523**	.555**	.319**	.293**
7	Aspirations in science							1	.640**	.121	.350**
8	Experience of school science								1	.229**	.420**
9	Parental support & involvement									1	.250*
10	Peer orientation to school & science										1

Notes: $^{**}p < .01$, $^{*}p < .05$.

cohesion text after controlling for sex and age (see Tables 3 and 4). Across both regression models, Variance Inflation Factors (VIF) for the predictor variables ranged from 1.02 to 2.05, below the threshold values (VIF of 10 or at least 5) that are used as rationale to suggest collinearity between the independent variables (Kutner *et al.*, 2004).

For high cohesion comprehension (Table 3), in Step 1, sex and age failed to reach statistical significance ($r = .10$, $r^2 = .01$, adj $r^2 = -.01$; $F\ (2, 103) = .519$, $p = .597$) indicating that these variables were unable to predict performance with high cohesion text. In Step 2, the inclusion of scores of on the individual difference tests showed a

Table 3. *A 2-step model for predicting comprehension performance of high cohesion text*

	B	**β**	***t***	***p***
Step 1				
Sex	.147	.054	.538	.591
Age	.247	.078	.785	.434
Step 2				
Sex	.003	.001	.014	.989
Age	.202	.064	.733	.465
Reading ability	.047	.403	3.96	.000
General intelligence	.050	.082	.879	.382
Aspirations in science	.088	.235	1.99	.051
Experience of school science	-.026	-.073	-.578	.565
Parental support & involvement	-.071	-.123	-1.21	.228
Peer orientation to school	.024	.046	.462	.645
Conscientiousness	-.006	-.034	-.340	.734
Science self-concept	.018	.066	.847	.399

B = unstandardized coefficient. β= standardised coefficient

Table 4. A 2-step model for predicting comprehension performance of low cohesion text

	B	β	*t*	*p*
Step 1				
Sex	.208	.068	.686	.494
Age	.571	.162	1.64	.104
Step 2				
Sex	.193	.063	.654	.515
Age	.508	.144	1.52	.131
Reading ability	.036	.274	2.50	.014
General intelligence	.060	.088	.869	.387
Aspirations in science	–.010	–.023	–.180	.857
Experience of school science	.031	.078	.571	.569
Parental support & involvement	.012	.019	.173	.863
Peer orientation to school	.072	.123	1.15	.251
Conscientiousness	.007	.031	.290	.772
Science self-concept	.010	.045	.369	.713

B = unstandardized coefficient. β= standardised coefficient.

regression model that reached statistical significance (r^2 change = .31; F change (8, 93) = 5.23; r = .56, r^2 = .31, adj r^2 = .24, F = 4.33, $p < .001$) with reading ability and aspirations in science demonstrating a statistically significant regression coefficient (p = .000 and p = .05, respectively). This suggests that having a higher reading ability and having higher aspirations in science predicts a facilitation of comprehension performance when reading high cohesion text.

For low cohesion comprehension (Table 4), in Step 1, sex and age failed to reach statistical significance (r = .18, r^2 = .03, adj r^2 = .02; F (2, 103) = .1.76, p = .177) indicating that these variables were unable to predict performance with low cohesion text. In Step 2, the inclusion of all the variables produced a regression model that reached statistical significance (r^2 change = .17; F change (8, 93) = 2.58; r = .46, r^2 = .21, adj r^2 = .13, F = 2.56, p = .01) with reading ability demonstrating a statistically significant regression coefficient (p = .01). This suggests that higher reading ability predicts higher levels of comprehension with low cohesion text.

In summary, the findings show that students' comprehension of science is superior after reading high cohesion text than low cohesion text. Higher reading abilities predicted increased comprehension with both high and low cohesion text designs. High aspirations in science predicted greater comprehension from high cohesion text.

Discussion

With the aim of investigating the importance of local cohesion in science textbook designs, and the role of individual differences in determining secondary school students' understanding of science text in the classroom, we compared comprehension accuracy after reading high and low cohesion text and measured individual differences. Three key findings emerged. Firstly, local text cohesion is important in determining students' comprehension of science text, with high cohesion text facilitating performance on MCQs greater than low cohesion text. Secondly, reading ability is a key predictor of performance on both high and low cohesion text. Thirdly, scores on the positive aspirations scale predicts comprehension with high cohesion text, but not low cohesion text.

The importance of local cohesion text designs is consistent with previous findings reporting improved comprehension with increased text cohesion (e.g., Beck *et al.*, 1991; Linderholm *et al.*, 2000). It is thought that text which is high cohesion increases recall and performance on multiple choice questions because it is easier to read and consolidate to memory (McNamara *et al.*, 1996). To explain further, it is widely believed that sound reading comprehension is strongly reliant on both the development and retrieval of an accurate mental representation of the situation described in the text (see Zwaan & Radvansky, 1998). High cohesion text promotes the formation of coherent mental representations because it explicitly links sentences together which enables each text unit to be processed in a meaningful way (Kintsch, 1998). Additionally, the linking of sentences and linguistic units strengthens memory traces, by co-activating information that has previously been read (e.g., Cook *et al.*, 1998). It is thought that these factors contribute to improved memory recognition and recall, which then enhances performance on MCQs.

Our findings provide support for previous research implicating a link between reading ability and the comprehension of science text (O'Reilly & McNamara, 2007; Schatschneider *et al.*, 2007; Ozuru *et al.*, 2009), and the importance of positive educational aspirations in determining academic performance (Rothon *et al.*, 2011). However, our study makes three important extensions to these findings.

Firstly, the majority of existing research has examined the influence of text cohesion on non-scientific text (narrative or expository). Studies which have examined scientific text comprehension to date have largely ignored students at the start of secondary education, instead focussing on undergraduate students (e.g., Ozuru *et al.*, 2009) or older primary school children (Best *et al.*, 2006; McNamara *et al.*, 2011). By examining comprehension of *science text* in early *secondary school* students we show that local text cohesion is important at this crucial stage in scientific education, which is likely to have implications for promoting scientific attainment and interest.

Secondly, previous research has suggested that skilled readers gain the most benefit from reading high cohesion text, possibly because they are equipped with the core skills needed to process the increased text-density associated with highly cohesive text (e.g., Beck *et al.*, 1991; Ozuru *et al.*, 2009). Here we find that skilled readers also perform better with low cohesion text, suggesting that the ability to deal with dense text (associated with high cohesion) may not be the sole reason for better comprehension. It appears that good reading skills also equip students with the ability to make inferences to maintain local text coherence, which promotes comprehension with low cohesion text (Millis *et al.*, 1995; Daneman & Hannon, 2001; Prat *et al.*, 2011). Therefore, strategies which aim to improve students' general reading ability may not only improve their core reading skills (e.g., letter identification, word meaning) but also subsequently enhance their inferential abilities and consequently their abilities to learn from both high and low cohesion text.

Thirdly, we show that the relationship between positive aspirations and academic attainment (Rothon *et al.*, 2011) is evident at a subject-specific level; positive *science* aspirations predicted increased comprehension from *science* text. However, this was only evident for high cohesion text. Therefore, it seems that positive aspirations interact with science attainment for arguably easier comprehension tasks, possibly because of the differing attentional demands associated with processing high and low cohesion texts. Scores for 'positive aspirations' were obtained from a sub-scale of the Science Aspirations and Careers Paradox (DeWitt et al., 2011) questionnaire. This is a relatively new scale which has been developed as part of a longitudinal study investigating factors which influence educational choices. The findings from this study highlight the potential validity of this tool in predicting students' comprehension of science texts.

Although the scores on the other individual difference scales employed correlated with performance on high and low cohesion text, they did not make significant independent contributions to predicting performance. As such, it seems that reading ability alone is a predominant mediating factor for science comprehension in young secondary school students. However, this study focussed on one specific key aspect of science achievement, the ability to comprehend locally high and low cohesive text as assessed by MCQ accuracy. Future research may further assess the role of individual differences and science achievement in science text comprehension using a range of additional methods, such as a free-flow writing task and a practical assessment, which allow for students' comprehension to be measured with less dependency upon strong reading skills.

Additionally, whilst the present research has made a valuable start in examining comprehension skills using 'offline' measures (MCQs after reading the text), using 'online' measures such as the time taken to read sentences in a text comprehension task (Graesser *et al.*, 1980) may further our understanding of how and at what stage of the comprehension process do individual differences influence students' ability to read high and low cohesion text. Research using online techniques to study science text comprehension has to date focussed on the performance of adults and college-aged children. However, these methods also have the capacity to reveal individual differences in younger reader's processing of textual coherence while reading about science. Having established that text coherence does influence students' offline comprehension processes we can begin to explore online measures in future investigations. Studies that have employed online approaches generally use much larger stimulus sets than in the present experiment. Consequently, further studies that investigate the effects of text cohesion on online text comprehension by younger participants will also be able to extend the present findings by demonstrating the generality of these effects across a broader variety of science topics. In the present study, each participant read only two high and two low cohesions texts (on different science topics), and answered only three MCQ questions for each topic in the experimental task, due to time constraints. As such, it will be important for future research to use a broader set of science texts to demonstrate the generality of these findings. Nevertheless, the present finding that even this relatively small stimulus set used in the present experiment can reveal significant effects of text cohesion on performance may attest to the importance of the influence of text cohesion on science text comprehension for this age group.

A further concern may be that participants were given an unlimited time to read each text before answering the MCQs in the present study. Care was taken to ensure that the order of presentation of texts was counterbalanced across the participant group, to avoid order effects that may reflect changes in motivation or attention to the task over time. Moreover, the present findings show that clear differences in comprehension accuracy are observed even under conditions in which participants can take as long as they wish to read high and low cohesion text. This is of particular importance in the context of an investigation of individual differences (including motivational differences) in comprehension, and so we deliberately chose not to restrict the time available to read each text. Rather we wished to see how these individual differences would influence comprehension in a typical classroom situation and duration (e.g., one hour lesson). Nevertheless, having established the importance of local text cohesion and reading ability on immediate science comprehension under the conditions used in the present study, an important next step will be to investigate these influences at delayed testing stages, such is common for academic assessments, and also their influence on participants' reading times for science texts. Indeed, it will be important for this research to establish whether the same individual factors or additional individual differences are important for determining performance in these tasks.

The findings reported here have significant implications for the design of Key Stage 3 (11–14 years) science textbooks. Analyses of science text typically report that the structure is lacking in cohesion (Beck *et al*., 1991; Best *et al*., 2005), yet the present findings show that students learn more effectively from science text that is high in local cohesion. It seems imperative that science textbooks are produced in a manner that maximises cohesion; by adding connectives, reducing the use of pronouns and elaborating on concepts.

Additionally, teachers should be aware of the importance of factors affecting the coherence of classroom dialogue. Indeed, research has highlighted the importance of teacher-talk in science lessons (Ogborn *et al*., 1996; Mortimer & Scott, 2003). To elaborate, when presenting written information to students it may prove beneficial to explicitly point out the links, or encourage the student to make local inferences, between the different parts of the text. For example, take a typical classroom situation where the teacher presents factual information on a projector at the start of a lesson:

> Heated solid particles vibrate faster. Particles start to break free from each other. Solids melt into a liquid. Particles move even faster until they are in random motion if the liquid is heated more. The liquid will become a gas. This is called evaporation.

After reading this the teacher may then encourage local text comprehension by promoting enquiry based upon linking meaning between the sentences. For example, 'Why did the particles break free from each other?' (answer—because the solid was heated), 'Why did the solid melt? (because the particles broke free from each other), 'What is evaporation?' (linking the demonstrative pronoun 'this', when a liquid becomes a gas). By encouraging students to achieve local text cohesion, this may increase comprehension (therefore attainment) in science, as well as developing the necessary skills to independently achieve local cohesion during self-regulated learning times, including revision for examinations.

The overarching significance of reading ability highlights the need to improve basic reading skills and teach reading strategies (e.g., inference making) to improve comprehension (see, e.g., McNamara, 2009; McNamara & Kendeou, 2011). Other issues that may be important include promoting interest in, and the value of pursuing scientific careers. For example, engaging active scientists and engineers in classroom activities can provide an out-of-classroom context for their science learning, which has shown to be beneficial for achievement (Gilbert & Priest, 1997) as well promoting interest in a science-based career. Research suggests that science achievement is higher if personally relevant (Reiss, 2000).

Conclusion

Beginning secondary school students demonstrated greater understanding of science text in a classroom exercise when the text was high in local cohesion. Higher reading skills predicted increased performance with both high and low local cohesion texts. Positive aspirations in science predicted better performance with high cohesion text. These results have significant implications for the design of science text and teaching strategies of secondary school science. In order to promote science achievement and interest it is important to pursue the role of local text cohesion, reading ability and scientific aspirations.

Acknowledgements

This research was financially supported by The Leverhulme Trust. Project title 'Improving Secondary School Students' Science Text Comprehension', RPG-094.

References

Alderton, D. L. & Larson, G. E. (1990) Dimensionality of Raven's Advanced Progressive Matrices items, *Educational and Psychological Measurement*, 50(4), 887–900.

Arthur, W. . Jr, Tubre, T. C., Paul, D. S. & Sanchez-Ku, M. L. (1999) College-sample psychometric and normative data on a short form of the Raven advanced progressive matrices test, *Journal of Psychoeducational Assessment*, 17(4), 354–361.

Aschbacher, P. R., Li, E. & Roth, E. J. (2010) Is science me? High school students' identities, participation and aspirations in science, engineering and medicine, *Journal of Research in Science Teaching*, 47(5), 564–582.

Beck, I. L., McKeown, M. G., Omanson, R. C. & Pople, M. T. (1984) Improving the comprehensibility of stories: The effects of revisions that improve coherence, *Reading Research Quarterly*, 19(3), 263–277.

Beck, I. L., McKeown, M. G., Sinatra, G. M. & Loxterman, J. A. (1991) Revising social studies text from a text processing perspective: Evidence of improved comprehensibility, *Reading Research Quarterly*, 26(3), 251–276.

Benbow, C. P., Arjmand, O. & Walberg, H. J. (1991) Educational productivity predictors among mathematically talented students, *Journal of Educational Research*, 84(4), 215–223.

Best, R. M., Rowe, M. P., Ozuru, Y. & McNamara, D. S. (2005) Deep-level comprehension of science texts: The role of the reader and the text, *Topics in Language Disorders*, 25(1), 65–83.

Best, R., Ozuru, Y., Floyd, R. & McNamara, D. S. (2006) Children's text comprehension. Effects of genre, knowledge, and text cohesion, in: S. A. Barab, K. E. Hay, D. T. Hickey (Eds) *Proceedings of the Seventh International Conference of the Learning Sciences* (Mahwah, NJ, Erlbaum), 37–42.

Bors, D. A. & Stokes, T. L. (1998) Raven's advanced progressive matrices: Norms for first-year university students and the development of a short form, *Educational & Psychological Measurement*, 58(3), 382–398. DOI: 10.1177/0013164498058003002.

Brown, J. A., Fishco, V. V. & Hanna, G. (1993) *Nelson–Denny Reading Test: Manual for scoring and interpretation, forms G & H* (Rolling Meadows, IL, Riverside Publishing).

Cain, K. & Oakhill, J. (2004) Reading comprehension difficulties, in: T. Nunes, P. Bryant (Eds) *Handbook of children's literacy* (Dordrecht, Kluwer Academic Publishers).

Catts, H., Adlof, S. M. & Weismer, S. E. (2006) Language deficits in poor comprehenders: A case for the simple view of reading, *Journal of Speech, Language and Hearing Research*, 49(2), 278–293.

Chamorro-Premuzic, T. & Furnham, A. (2003) Personality predicts academic performance: Evidence from two longitudinal studies on university students, *Journal of Research in Personality*, 37(4), 319–338.

Chapman, C. & Sheehan, M. (2003) *Catalyst: A framework for success* (Oxfordshire, Heinemann Educational).

Collins, K. M. T. & Onwuegbuzie, A. J. (2002) Reading ability and the performance of African American graduate students in research methodology courses, *The Journal of College Literacy and Learning*, 31, 39–52.

Cook, A. E., Halleran, J. G. & O'Brien, E. J. (1998) What is readily available? *A memory-based view of text processing, Discourse Processes*, 26(2&3), 109–129.

Costa, P. T. . Jr & McCrae, R. R. (1992) *The Revised NEO Personality Inventory (NEO-PI-R) and NEO Five-Factor Inventory (NEO-FFI) professional manual. Psychological assessment resource*s. (Odessa, FL, Psychological Assesement Resources, Inc.).

Daneman, M. & Hannon, B. (2001) Using working memory theory to investigate the construct validity of multiple-choice reading comprehension tests such as the SAT, *Journal of Experimental Psychology: General*, 130(2), 208–223.

DeWitt, J., Archer, L., Osborne, J., Dillon, J., Willis, B. & Wong, B. (2011) High aspirations but low progression: The science aspirations-careers paradox amongst minority ethnic students, *International Journal of Science and Mathematics Education*, 9(2), 243–271.

DiPerna, J. C. (2006) Academic enablers and student achievement: Implications for Assessment and intervention services in the schools, *Psychology in the Schools*, 43(1), 7–17.

Duncan, G., Boisjoly, J. & Harris, K. M. (2001) Sibling, peer, neighbour, and schoolmate correlations as indicators of the importance of context for adolescent development, *Demography*, 38(3), 437–447.

Eilam, B., Zeidner, M. & Aharon, I. (2009) Student conscientiousness, self-regulated learning, and science achievement: An explorative field study, *Psychology in the Schools*, 46(5), 420–432.

Fesit, G. (2012) Predicting interest in and attitudes toward science from personality and need for cognition, *Personality & Individual Differences*, 52(7), 771–775.

Field, A. F. (2009) *Discovering statistics using SPSS* (3rd ed.) (Thousand Oaks, CA, Sage).

Foskett, N. H. & Hemsley-Brown, J. (2001) *Choosing futures: Young people's decision-making in education, training and careers markets* (London, Routledge Falmer).

Gilbert, J. (2006) *Science education in schools: Issues, evidence and proposals* (London, TRLP).

Gilbert, J. & Priest, M. (1997) Models and discourse: A primary school science class visit to a museum, *Science Education*, 81(6), 749–762.

Gonzalez-DeHass, A. R., Willems, P. & Doan Holbein, M. (2005) Examining the relationship between parent involvement and student motivation, *Educational Psychology Review*, 17(2), 99–123.

Graesser, A. C., Hoffman, N. L. & Clark, L. F. (1980) Structural components of reading time, *Journal of Verbal Learning and Verbal Behavior*, 19(2), 131–151.

Graesser, A. C., McNamara, D. S. & Louwerse, M. M. (2003) What do readers need to learn in order to process coherence relations in narrative and expository text?, in: A. P. Sweet, C. E. Snow (Eds) *Rethinking reading comprehension* (New York, Guilford), 82–98.

Hammel, R. & Schmittmann, V. D. (2006) The 20-minute version as a predictor of the Raven Advanced Progressive Matrices Test, *Educational & Psychological Measurement*, 66(6), 1039–1046.

Harcourt Assessment (2003) *Raven's Advanced Progressive Matrices and Mill Hill Vocabulary Scale: Occupational user's guide* (Oxford, Harcourt Assessment).

Hawes, A., Heerman, C. E., Lamb, B., Lowenstein, C. K. & Seltzer, K. N. (1982) Correlations of scores in the Nelson–Denny reading tests, form E, and measures of academic aptitude, academic achievement, readers' attitude, and students' self-concept, *Psychological Reports*, 51, 229–230.

Just, M. A. & Carpenter, P. A. (1992) A capacity theory of comprehension: Individual differences in working memory, *Psychological Review*, 98(1), 122–149.

Kifer, E. A. (2002) Students' attitudes and perceptions, in: D. F. Robataille, A. E. Beaton (Eds) *Secondary analysis of the TIMSS data* (Boston, MA, Kluwer Academic), 251–275.

Kintsch, W. (1998) *Comprehension: A paradigm for cognition* (New York, Cambridge University Press).

Kintsch, W. (2009) Learning and constructivism, in: S. Tobias, T. M. Duffy (Eds) *Constructivist theory applied to instruction: Success or failure?* (Mahwah, NJ, Lawrence Erlbaum Associates), 223–241.

Kline, P. (1986) *Handbook of test construction* (London, Routledge and Kegan Paul).

Konstabel, K., Lönnqvist, J., Walkowitz, G., Konstabel, K. & Verkasalo, M. (2012) The 'Short Five' (S5): Measuring personality traits using comprehensive single items, *European Journal of Personality*, 26(1), 13–29.

Kutner, M. H., Nachtsheim, C. J., Neter, J. & Li, W. (2004) *Applied linear statistical models* (5th ed.) (Chicago, McGraw-Hill & Irwin).

Linderholm, T., Everson, M. G., van den Broek, P., Mischinski, M., Crittenden, A. & Samuels, J. (2000) Effects of causal text revisions on more and less-skilled readers' comprehension of easy and difficult narrative texts, *Cognition and Instruction*, 18(4), 525–556.

Long, D. L. & Lea, R. B. (2005) Have we been searching for meaning in all the wrong places? De-fining the 'search after meaning' principle in comprehension, *Discourse Processes*, 39(2&3), 279–298.

Marsh, H. W. (1990a) The causal ordering of academic self-concept and academic achievement: A multiwave, longitudinal panel analysis, *Journal of Educational Psychology*, 82(4), 646–656.

Marsh, H. W. (1990b) A multidimensional, hierarchical self-concept: Theoretical and empirical justification, *Educational Psychology Review*, 2(2), 77–172.

Marsh, H. W. (1992) *Self-Description Questionnaire II: Manual* (New South Wales, Australia, University of Western Sydney, Macarthur, Faculty of Education, Publication Unit).

Marsh, H. W. (1993) Academic self-concept. Theory measurement and research, in: J. Suls (Ed.) *Psychological perspectives on the self* (Hillsdale, NJ, Erlbaum), Vol. 4, 59–98.

Marsh, H. W. & Hau, K. T. (2004) Explaining paradoxical relations between academic self-concepts and achievements: Cross-cultural generalizability of the internal–external frame of reference predictions across 26 countries, *Journal of Educational Psychology*, 96(1), 56–67.

Matthews, G., Zeidner, M. & Roberts, R. (2006) *The science of emotional intelligence: Knowns and unknowns* (New York, Oxford University Press).

McNamara, D. S. (2009) The importance of teaching reading strategies. Perspectives on language and literacy, *The International Dyslexia Association*, 3(2), 4–40.

McNamara, D. S. & Kendeou, P. (2011) Translating advances in reading comprehension research to practice, *International Electronic Journal of Elementary Education*, 4, 33–46.

McNamara, D. S., Kintsch, E., Songer, N. B. & Kintsch, W. (1996) Are good texts always better? *Text coherence, background knowledge, and levels of understanding in learning from text, Cognition & Instruction*, 14(1), 1–43.

McNamara, D. S., Louwerse, M. M., McCarthy, P. M. & Graesser, A. C. (2010) Coh-metrix: Capturing linguistic features of cohesion, *Discourse Processes*, 47(4), 292–330.

McNamara, D. S., Ozuru, Y. & Floyd, R. G. (2011) Comprehension challenges in the fourth grade: The roles of text cohesion, text genre, and readers' prior knowledge, *International Electronic Journal of Elementary Education*, 4(3), 229–257.

Meyer, M. S. (2000) The ability–achievement discrepancy: Does it contribute to an understanding of learning disabilities?, *Educational Psychology Review*, 12(3), 315–337.

Millis, K. K., Golding, J. M. & Barker, G. (1995) Causal connectives increase inference generation, *Discourse Processes*, 20(1), 29–49.

Möller, J., Pohlmann, B., Köller, O. & Marsh, H. W. (2009) A meta-analytic path analysis of the internal/external frame of reference model of academic achievement and academic self-concept, *Review of Educational Research*, 79(3), 1129–1167.

Mortimer, E. F. & Scott, P. H. (2003) *Meaning making in secondary science classrooms* (Buckingham, Open University Press).

Nichols, J. D. & White, J. (2001) The impact of peer networks on achievement from lower and upper track algebra students, *Journal of Educational Research*, 94(5), 267–273.

Noftle, E. E. & Robins, R. W. (2007) Personality predictors of academic outcomes: Big five correlates of GPA and SAT scores, *Journal of Personality and Social Psychology*, 93(1), 116–130.

Norris, S. & Phillips, L. (2003) How literacy in its fundamental sense is central to scientific literacy, *Science Education*, 87(2), 224–240.

O'Reilly, T. & McNamara, D. S. (2007) Reversing the Reverse Cohesion Effect: Good texts can be better for strategic, high knowledge readers, *Discourse Processes*, 43(2), 121–152.

Oakhill, J. & Yuill, N. (1996) Higher order factors in comprehension disability: Processes and remediation, in: C. Cornoldi, J. Oakhill (Eds) *Reading comprehension difficulties: Processes and intervention* (New Jersey, NJ, Lawrence Erlbaum).

Oakhill, J. V., Cain, K. & Bryant, P. E. (2003) The dissociation of word reading and text comprehension: Evidence from component skills, *Language and Cognitive Processes*, 18(4), 443–468.

Ogborn, J., Kress, G., Martins, I. & McGillicuddy, K. (1996) *Explaining science in the classrooms* (Buckingham, Open University Press).

Osborne, J. F. & Collins, S. (2001) Pupils' views of the role and value of the science curriculum: A focus group study, *International Journal of Science Education*, 23(5), 441–468.

Osborne, J. F., Simon, S. & Collins, S. (2003) Attitudes towards science: A review of the literature and its implications, *International Journal of Science Education*, 25(9), 1049–1079.

Ozuru, Y., Briner, S., Best, R. & McNamara, D. S. (2010) Contributions of self-explanation to comprehension of high and low cohesion texts, *Discourse Processes*, 47(8), 641–667.

Ozuru, Y., Dempsey, K. & McNamara, D. S. (2009) Prior knowledge, reading skill, and text cohesion in the comprehension of science texts, *Learning and Instruction*, 19(3), 228–242.

Perfetti, C. A. (1985) *Reading ability* (New York, Oxford University Press).

Prat, C. S., Mason, R. A. & Just, M. A. (2011) Individual differences in the neural basis of causal inferencing, *Brain and Language*, 116(12), 1–13.

Primor, L., Pierce, M. E. & Katzir, T. (2011) Predicting reading comprehension of narrative and expository texts among Hebrew-speaking readers with and without a reading disability, *Annals of Dyslexia*, 61(2), 242–268.

Raven, J., Raven, J. C. & Court, J. H. (1998) *Raven manual: Section 1. General overview* (Oxford, Oxford Psychologist Press).

Reiss, M. J. (2000) *Understanding science lessons: Five years of science teaching* (Buckingham, Open University Press).

Roberts, G. (2002) *SET for success: The supply of people with science, technology, engineering and mathematics skills* (London, HM Treasury).

Robinson, D., Gabriel, N. & Katchan, O. (1994) Personality and second language learning, *Personality and Individual Differences*, 16(1), 143–157.

Rogers, M. A., Theule, J., Ryan, B. A., Adams, G. R. & Keating, L. (2009) Parental involvement and children's school achievement: Evidence for mediating processes, *Canadian Journal of School Psychology*, 24(1), 34–57.

Rothon, C., Arephin, M., Klineberg, E., Cattell, V. & Stansfeld, S. (2011) Structural and socio-psychological influences on adolescents' educational aspirations and subsequent academic achievement, *Social Psychology of Education*, 14(2), 209–231.

Sadeghi, N., Kasim, Z. M., Tan, B. H. & Abdullah, F. S. (2012) Learning styles, personality types and reading comprehension performance, *English Language Teaching*, 5(4), 116–123.

Schatschneider, C., Harrell, E. & Buck, J. (2007) An individual differences approach to the study of reading comprehension, in: R. K. Wagner, A. E. Muse, K. R. Tannenbaum (Eds) *Vocabulary acquisition: Implications for reading comprehension* (New York, The Guilford Press), 249–275.

Seginer, R. (2006) Parents' educational involvement: A developmental ecology perspective, *Parenting*, 6(1), 1–48.

St George, M., Mannes, S. & Hoffman, J. E. (1997) Individual differences in inference generation: An ERP analysis, *Journal of Cognitive Neuroscience*, 9(6), 776–787.

Strauss, E., Sherman, E. M. S. & Spreen, O. (2006) *A compendium of neuropsychological tests: Administration, norms and commentary* (3rd ed.) (New York, NY, Oxford University Press).

Tiu, R. D., Thompson, L. A. & Lewis, B. A. (2003) The role of IQ in a component model of reading, *Journal of Learning Disabilities*, 36(5), 424–436.

Valentine, J. C., DuBois, D. L. & Cooper, H. (2004) The relation between self-beliefs and academic achievement: A meta-analytic review, *Educational Psychologist*, 39(2), 111–133.

Van der Elst, W., Ouwehand, C., van Rijn, P., Lee, N., Van Boxtel, M. & Jolles, J. (2011) The shortened Raven standard progressive matrices: Item response theory-based psychometric analyses and normative data, *Assessment*. Available online at: http://dl.dropbox.com/u/

8416806/Website/Van%20der%20Elst%20et%20al.%2C%202011e.pdf (accessed August 2011).

Vellutino, F. R., Scanlon, D. M., Small, S. G. & Tanzman, M. S. (1994) Components of reading ability: Issues and problems in operationalizing word identification, phonological coding, and orthographic coding, in: G. R. Lyon (Ed.) *Frames of reference for the assessment of learning disabilities: New views on measurement issues* (Baltimore, MD, Brookes), 279–324.

Wilkins, J. L. M., Zembylas, M. & Tarvers, K. J. (2002) Investigating correlates of mathematics and science literacy in the final year of secondary school, in: D. F. Robataille, A. E. Beaton (Eds) *Secondary analysis of the TIMSS data* (Boston, MA, Kluwer Academic), 291–316.

Wood, P. (1982) The Nelson–Denny reading tests as a predictor of college freshmen grades, *Educational and Psychological Measurement*, 42(2), 575–683.

Zwaan, R. A. & Radvansky, G. A. (1998) Situation models in language comprehension and memory, *Psychological Bulletin*, 123(2), 162–1855.