Learning and Individual Differences 29 (2014) 74–80

Contents lists available at ScienceDirect

Learning and Individual Differences

journal homepage: www.elsevier.com/locate/lindif

Individual differences in the effectiveness of text cohesion for science text comprehension

Sophie Hall [a,*], Jaskaran Basran [a], Kevin B. Paterson [a], Rebecca Kowalski [a], Ruth Filik [b], John Maltby [a]

[a] Henry Wellcome Building, College of Medicine, Biological Sciences and Psychology, University of Leicester, Lancaster Road, Leicester LE1 9HN, UK
[b] School of Psychology, University Park, The University of Nottingham, Nottingham NG7 2RD, UK

ARTICLE INFO

Article history:
Received 22 October 2012
Received in revised form 23 September 2013
Accepted 23 October 2013

Keywords:
Text cohesion
Science learning
Individual differences
General intelligence
Self-efficacy

ABSTRACT

The present study examined associations between individual differences and comprehension capabilities of secondary school children when reading texts about science topics of varying levels of cohesion (i.e. low versus high cohesion). We administered measures of learning after reading high and low cohesion texts (defined by repetition of nouns and phrases) to 60 students (31 boys, 29 girls) and measured cognitive ability, facets of conscientiousness, and science self-efficacy. Students achieved better learning from high cohesion text. High cognitive ability was associated with good performance with both texts, whereas low cognitive ability was associated with poor performance on low cohesion text. High science self-efficacy was associated with good performance on both texts, low science self-efficacy was associated with average performance with the texts. Low dutifulness (conscientiousness facet) was associated with poor performance on low cohesion text. These results have significant implications for the design of science textbooks and potential teacher intervention strategies with the aim of improving science education.

1. Introduction

There is growing awareness in many advanced societies of the need to encourage young people to study science in secondary levels of education and beyond, in order to increase the scientific skill base and maintain a strong workforce (e.g. Krajcik & Sutherland, 2010). However, students beginning compulsory science education often find science more difficult than other academic subjects (Jenkins & Nelson, 2005; Lyons, 2006; Osborne & Collins, 2001), and have particular difficulty in understanding scientific text (Bowen, 1999; Snow, 2002, 2010), which may dissuade them from following careers in science. Consequently, if we are to improve young students' understanding of science, it is important to increase our understanding of the causes of these comprehension difficulties, and to make science more accessible to a broader range of students.

1.1. The importance of text cohesion

It is widely argued that successful text comprehension relies on the reader forming a coherent mental representation of the text (Ehrlich, 1991; Graesser, Millis, & Zwaan, 1997; McNamara, Louwerse, McCarthy, & Graesser, 2010). Text cohesion refers to the degree to which concepts, ideas, and relations within a text design are made explicit, and this influences our ability to form mental representations (Graesser, McNamara, & Louwerse, 2003; Graesser, McNamara, Louwerse, & Cai, 2004; O'Reilly & McNamara, 2007). However, science text is often structured so that logical connections and meanings between the sentences are difficult to infer (low cohesion text), making science text particularly hard to understand (Kamberelis, 1999). Specifically, 'high cohesion' text which explicitly links referents in sentences, by avoiding the use of pronouns (e.g. 'them', 'it') and instead using noun-repetition, improves comprehension (Graesser et al., 2003). Other cohesive text variables include explicit logical connections and signalling words that make relationships explicit. When these relationships are not explicit, readers have to infer relationships between different linguistic expressions, and this can be a source of comprehension difficulty (Graesser, McNamara, & Louwerse, 2003). Research on adults and college-aged students has shown that increasing text cohesion can benefit comprehension (e.g. Ehrlich & Remond, 1997; Ozuru, Briner, Best, & McNamara, 2010; Ozuru, Dempsey, & McNamara, 2009). In particular, text which is high cohesion increases recall and performance on multiple choice questions (McNamara & Kintsch, 1996), because it is easier to read and consolidate to memory (McNamara, Kintsch, Songer, & Kintsch, 1996). To further explain, successful language comprehension is thought to be strongly reliant on 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 (e.g. Graesser et al., 2004) and therefore improves memory recognition and recall.

Text cohesion in science texts is particularly poor in comparison to narrative style text (Beck, McKeown, Sinatra, & Loxterman, 1991). Notably, academics typically use a high frequency of pronouns in preference to less ambiguous nouns and using repetition of nouns and phrases

* Corresponding author. Tel.: +44 7817139077.
E-mail addresses: sophie.hall@dmu.ac.uk (S. Hall), kbp@leicester.ac.uk (K.B. Paterson), Ruth.filik@nottingham.ac.uk (R. Filik), jm148@leicester.ac.uk (J. Maltby).

1041-6080/$ – see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.lindif.2013.10.014

(Gray, 2006 in Gray, 2010; Swales, 2005). Therefore, students' ability to comprehend science text is likely to be strongly mediated by the reader's ability to achieve cohesion between the sentences. However, the effects of text cohesion have predominantly been investigated using an adult (under-graduate) sample. Although a review by Best, Rowe, Ozuru, and McNamara (2005) suggests that similar benefits may be observed with younger school children the experimental evidence to support this has primarily used children who have not started secondary science education (7–10 years) and have used narrative text styles (Cain, 2003; Cain & Nash, 2011). Two studies which have used science text with children have shown little effect of text cohesion in science comprehension, when text cohesion is modulated by a range of variables (avoiding pronouns, elaborating on concepts, use of connectives, conceptual overlap) (Best, Ozuru, Floyd, & McNamara, 2006; McNamara, Ozuru, & Floyd, 2011). However, a study, by McNamara et al. (1996), showed that 11–15 year olds' ability to comprehend biology text (about mammals) was better when the text was expanded upon and had high cohesion. Although McNamara et al.'s (1996) study provides promise for the effects of text cohesion with secondary school children, only 12 children, with a 4 year age range, were tested on each text design. Additionally, the texts were revised to add information which explicitly identified that the subtopics in the paragraph were talking about traits of mammals, and did not look specifically at the effects of repetition of referential nouns and of phrases.

Despite the increasing policy concern that students starting secondary education regress in their interest and attainment in science (Galton, 2009), it is clear that this age group (11–13 years) has largely been ignored in science reading comprehension studies. In order to identify ways to promote science attainment and interest in science it is essential that we understand how to best support science education at the beginning of secondary school. Evidence suggests that text cohesion, in particular the ability to achieve text cohesion (i.e. the ability to link the meaning between sentences with and without explicit links) is important to successful science comprehension (Beck et al., 1991). As such, this study focusses on beginning secondary school students' comprehension of high and low cohesion science texts, as determined by the use of repetition of referential nouns and of phrases/concepts.

1.2. The role of individual differences

Social cognitive theory emphasises that general intelligence and learning (i.e. academic achievement) are not simply the product of taking in information, but instead result from active interpretation of information which influences learning experiences (Bandura, 1977). Within social cognitive theory self-efficacy and personality are key learnt behaviours which are integral to determining task achievement on academic tests. Self-efficacy is a learned behaviour of perceived task competence which explains how an individual approaches goals and tasks. For example, high self-efficacy is associated with greater motivation and perseverance to achieve tasks (e.g. Crothers, Hughes, & Morine, 2008). Specific to self-efficacy and science, evidence suggests that self-efficacy and competence in science are related to general science achievement (Wang, Oliver, & Staver, 2008), but this has yet to be examined in terms of learning from science text. With regard to personality, the conscientiousness facet of the five-factor model of personality has been widely reported as being a key personality-type predictor of academic performance (e.g. Noftle & Robins, 2007) particularly with children in the middle years of compulsory education (i.e. early secondary school) (Laidra, Pullmann, & Allik, 2007). Conscientiousness can be defined as the tendency to show self-discipline, act dutifully, and aim for achievement (Costa & McCrae, 1992). Recently, conscientiousness has been related to achievement in science (Eilam, Zeidner, & Aharon, 2009; Fesit, 2012), but has not been explored specifically to learning from science text. A recent review appealed for more research to examine potential relationships between personality traits and reading comprehension in determining academic attainment (Sadeghi, Kasim, Tan, & Abdullah, 2012), making it appealing to investigate the role of contentiousness to learning in science via reading. In support of the significance of the social cognitive theory model of learning in educational research, general cognitive ability (common performance on a range of cognitive tasks, see, Deary, Penke, & Johnson, 2010) and personality are well documented as being key factors in determining attainment (see, Chamorro-Premuzic & Furnham, 2005; Deary, 2012; Neisser et al., 1996), indeed, the primary objective of intelligence tests is to predict academic achievement (Ackerman & Heggestad, 1997). More pertinently to this research, general cognitive ability has been shown to predict reading comprehension of adults (Primor, Pierce, & Katzir, 2011) and children (Tiu, Thompson, & Lewis, 2003).

The rationale for focussing on intelligence and conscientiousness in this paper derives from the common sense notion that achievement is, broadly speaking, the result of ability and success (Gagné & St Pére, 2001). Given that science self-efficacy is learnt from previous successes and failures in the science classroom this factor is likely to be inherent to both ability and conscientiousness and therefore is important to include when considering individual differences in science learning. Accordingly, the aim of the present research was to establish the role of key individual differences (general intelligence, conscientiousness and self-efficacy in science) in predicting learning (as measured by comprehension) from scientific text in which the level of cohesion is varied.

2. Method

2.1. Participants

60 students (31 boys, 29 girls) from a general comprehensive secondary school in the East Midlands of England took part in the study. Participants' ages ranged from 12 to 14 years old with a mean (*M*) age of 12.75 and a standard deviation (*SD*) of .65. Participants were told that the study was concerned with the design of science text books. Parental consent was obtained for all participants. Testing procedures complied with BPS Ethics Code of Conduct (2009).

2.2. Materials

To assess the influence of text cohesion on comprehension ability, students were presented with six high and six low cohesion texts (12 texts in total). Using a paired sample design the texts were counterbalanced so that no participant saw both high and low cohesion versions of the text, but each text was seen across participants in both versions. These were adapted from academic science text books used for working towards the General Certificate of Secondary Education qualification (e.g. Gallagher & Ingram, 2000; Pople, 1999; Williams, 2006). High and low cohesion versions of each text were created following previously used methods (Ozuru et al., 2009). High cohesion text avoided the use of pronouns to refer to previously introduced noun-phrases, and included using argument overlap to ensure referential clarity. In summary, high cohesion text used more repetition of key nouns and phrases. Low cohesion text did not repeat facts and used pronouns to refer to key referents (see Fig. 1). To clarify, low cohesion texts avoided the use of repetitive phrases. For each text (high and low cohesion versions), three multiple choice questions (MCQs) were used to assess text comprehension (totalling 36 questions, 18 for each condition). These were designed to assess inferential levels of comprehension that are a hallmark of good science text comprehension rather than more superficial aspects of the text. To explain by example using the first two sentences in Fig. 1; in the low cohesion condition the target word 'Enzymes' is later referred to by the pronoun 'They'; '*Enzymes have become very important in the industry. They are versatile and far more efficient than other catalysts.*' For successful comprehension the student must remember that the referent in the first sentence was 'enzymes' and that 'they' refers to the 'enzymes'. To assess whether the student had correctly linked the two referents ('enzyme' and 'they') one of the multiple choice questions asked '*Why are enzymes important*