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Exploring relationships between working memory and writing: Individual differences associated with gender

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ABSTRACT

Gender differences in the relationships between working memory (short-term storage and combined storage and processing) in both the visuo-spatial and verbal domains and children's alphabet transcription and text writing abilities were investigated. Data from 81 children (43 males) aged between 5;2 to 8;5 revealed no significant group differences between boys and girls in working memory or writing performance. However, individual difference analyses demonstrated variation associated with age and gender in the memory skills underpinning writing. Regression analyses revealed that verbal short-term memory abilities predicted the alphabet transcription skills of boys but not girls. Although visuo-spatial short-term memory predicted writing quality in both genders, predictors of writing fluency differed with verbal working memory skills predicting boys' writing fluency and visuo-spatial short-term memory predicting writing fluency in girls. The need to consider gender differences more critically from the perspective of individual differences in cognitive skills underpinning writing development and the strategic application of these skills during writing is discussed.

1. Introduction

Since the inception of the English National Curriculum, increasing standards in reading and mathematics have been reported, although writing appears more resistant to improvement (DfE, 2012). The poor writing performance of boys relative to girls has been raised as an issue of particular concern in the UK and elsewhere (Lee, 2013; Miller & McCardle, 2011; Ofsted, 2003) with a gap of some 15%–19% in the proportion of boys leaving UK primary schools having attained expected levels in writing (DCSF, 2010).

1.1. Gender differences in writing development

Many factors have been proposed to underpin this gender divide; linguistic factors (Maccoby & Jacklin, 1974), attitudes towards writing (Knudson, 1995), motivation and self-efficacy (Klassen, 2002), teacher perceptions (Jones & Myhill, 2004) and individual differences in the cognitive skills underpinning writing. Within the latter context gender differences in writing have been investigated in detailed analyses of the writing product of factors proposed to support writing processes. Some studies report that girls produce text of a higher quality than boys. For example, Bourke & Adams (2011) found a significant advantage for girls at even the very earliest stages of writing development (aged 4–5 years) both when rated on a number of educationally relevant criteria and on the linguistic features of texts. Beard & Burrell (2010) assigning ordinal scores for ratings in categories such as purpose and organisation, grammar, spelling and handwriting to the texts of 9–10 year-old children also revealed a significant advantage for girls. Comparisons of the overall quality of the written product have not always identified gender differences though (Cameron et al., 1995; Williams & Larkin, 2013). Moreover, even when gender differences in quality have been claimed it may be necessary to interpret these with caution. For example both Stainthorp and Rauf (2009) and Berninger and Fuller (1992) reported gender differences in writing quality although significant interactions between age and gender which were not explored suggested an inconsistent developmental pattern. It may be especially difficult to elucidate gender differences in writing at the level of the linguistic or textual features which characterise overall impressions of quality (Berman & Verhoeven, 2002). Jones and Myhill (2007) found that gender differences graduated with increasing specificity of assessment from text level aspects of writing to sentence level features. Given such inconsistency further research examining the developmental pattern of gender differences in writing quality is certainly warranted.

Advantages for girls in writing fluency, the number of words produced within a given time limit, appear more reliably in the literature (Berninger & Fuller, 1992; Williams & Larkin, 2013) and it has been proposed that rather than difficulty composing the message boys may have particular problems with the mechanics of producing texts (Daly, 2003). Differences in handwriting fluency also have an impact on the quality of the text produced though (Connelly & Hurst, 2001). Berninger et al. (1996) found that higher ratings for the quality of girls' text content and organisation disappeared when compositional fluency was

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statistically controlled. Girls may automise lower level transcription skills earlier or more effectively than boys allowing them to focus on the later developing high-order composition skills which impact on perceptions of text quality (McCutchen, 1996). This account, based on the impact of working memory (WM) skills on writing, is consistent with more robust gender differences in writing fluency than writing quality.

1.2. Working memory and writing development

Models of WM include short-term storage (STM) alongside attentional and skill co-ordination processes required to complete complex, everyday tasks (Baddeley, 2007; Engle et al., 1999), although models differ in the extent to which these aspects are considered distinct (see Cowan, 2010; Miyake & Shah, 1999 for an overview). Writing is one such complex, resource demanding task, incorporating a spectrum of processes (e.g. generating ideas, translating these into linguistic forms to be transcribed) which together achieve the written product (Alamargot & Chanquoy, 2001). Research from a variety of WM perspectives has confirmed the important role WM plays in writing; in adults (Kellogg et al., 2013) in writing development (Bourke & Adams, 2010; McCutchen et al., 1994; Swanson & Berninger, 1996) and writing disabilities (Berninger, 2009).

In the simple view of writing (Berninger, 2000) transcription skills (handwriting and spelling) and attentional processes which control the cognitive resources underpin text generation and composition with all processing being conducted within the capacity limitations of WM. As writing develops from mark making through the production of individual words then phrases to structured, coherent text (Berninger & Chanquoy, 2012) so the underlying cognitive processes are proposed to change (Berninger & Swanson, 1994). For novice writers transcribing orthographic symbols is considered to be a far more resource-demanding process than for experienced writers (Berninger et al., 1992). Unpractised transcription skills demanding more of the limited WM resources divert resources away from high-level composing skills (McCutchen, 1996). Using structural equation modelling Wagner et al. (2011) confirmed this distinction of text quality from productivity and handwriting fluency in the elementary/primary grades. How the storage and attentional control features within WM may impact upon these different aspects of writing has also been explored. Differential relationships have been identified between WM capacity and compositional fluency and quality (Berninger et al., 1992), between text generation and transcription and verbal WM capacity versus STM (Swanson & Berninger, 1996) and between writing performance and STM and WM in both the visual and verbal domains (Vanderberg & Swanson, 2007). However, these studies examined the writing of children at very different stages of development and since associations between memory and writing vary depending on the writer's age and skill (Bourdin & Fayol, 1994) a complete developmental account, incorporating both storage and WM capacity in the visual and verbal domains has yet to be fully determined. The present study aims to identify the extent to which STM and WM in the visuo-spatial and verbal domains are associated with writing quality, writing fluency and basic transcription skills in the very early stages of writing.

1.3. Working memory, gender & writing

Surprisingly little evidence has examined whether differences in WM resources are able to account for variation in the development of writing across gender. Perhaps since gender differences in WM have generally neither been examined nor identified (Bourke & Adams, 2011; Pickering & Gathercole, 2001) they might seem an unpromising explanation of gender differences in writing despite their accepted role in developmental and individual difference accounts of writing abilities (Swanson & Berninger, 1996). A resolution to this paradox is not aided by the fact that the few published studies considering whether memory abilities might underpin gender differences in writing have provided equivocal evidence. Berninger et al. (2008) found in children with dyslexia that the poorer writing skills of boys were accompanied by poorer verbal WM. In contrast, although in much younger children (aged between 4 and 5 years), Bourke & Adams (2011) found that gender differences in writing were not accompanied by differences in WM. The situation may, however, be more complex than gender differences in writing arising from directly comparable differences in WM. It may be the application of available resources to support writing which differs between boys and girls.

Gender differences in the application of cognitive skills to tasks such as reading (Johnston & Thompson, 1989), mathematics (Carr & Davies, 2001) and writing (Berninger et al., 2008) have been identified. Such differences are usually interpreted within Siegler's (1996) overlapping waves model which proposes that the strategy an individual applies will be determined by their knowledge, their ability to apply the strategy and the demands of the task. Crucially strategy differences do not always translate to perceptions of task ability. Thompson (1987) found boys relied on a phonological reading strategy more than girls even when overall reading ability did not differ. Thus even in the presence of comparable WM skills and indeed writing ability girls and boys may differ in the way these skills are applied to support the writing process.

1.4. The present study

The extent to which memory processes are able to explain individual differences in writing both across and within gender is examined, addressing a number of related questions. First, are different aspects of memory related to writing fluency and quality measures? Measures of both storage (STM) and storage and processing reflecting WM capacity (WM) in both the verbal and the visual–spatial domains will be assessed (Conway et al., 2002). Second, are gender differences evident in all aspects of writing performance? Both writing quality and two measures of writing production, alphabet transcription and the number of words in the text (writing fluency) were analysed separately. This was to reflect debate regarding the distinction of text length from writing quality (Jewell & Malecki, 2005), the extent to which handwriting execution might be discriminated from writing fluency generally (Sumner et al., 2014) and their specific relationships with verbal STM (Adams et al., 2013). Third, are the relationships between memory and writing consistent across genders? Individual differences in the facility to support specific writing processes with particular memory skills may differentiate the performance of boys from girls.

2. Method

2.1. Participants

Ninety children from years 1 and 3 were recruited from six schools in North West England. Nine children who had English as a second language were excluded from the analyses. This resulted in a subsample of 81 children (43 males) ranging in age from 5;2 to 8;5 years. As an indication of socio-economic status, the proportion of children eligible for free school meals at the participating schools ranged from 7.4%–53.4% (mean 24.1% SD = 17.34) comparable to the national average of 19.3%.

2.2. Working memory measures

Six assessments representing two tasks for each memory component from the Automated Working Memory Assessment battery (AWMA, Alloway, 2007) a computer-based assessment were administered. For all tasks practice trials of two or three items with feedback were presented followed by six trials at each level of difficulty (block). If successful on the first four trials in a block credit was given for the remaining trials and the level of difficulty of the next block increased by one item. If unsuccessful on four or more trials in a block testing ceased for that task.