Read Writ (2013) 26:865–888
DOI 10.1007/s11145-012-9396-1

An evaluation of the written texts of children with SLI: the contributions of oral language, reading and phonological short-term memory

Clare J. Mackie · Julie Dockrell · Geoff Lindsay

Published online: 14 July 2012

Abstract In this study, we performed a fine grained analysis of writing by children with a specific language impairment (SLI) and examined the contribution of oral language, phonological short-term memory (STM), nonverbal ability, and word reading to three writing constructs (productivity, complexity and accuracy). Forty-six children with SLI were compared with 42 children matched for chronological age, receptive vocabulary ($N = 46$) and reading decoding ($N = 46$) on a measure of narrative writing. The SLI group performed worse on all measures compared to children of a similar chronological age. The SLI group produced a greater proportion of orthographic spelling errors than children with similar receptive vocabularies, but were comparable to children matched for reading decoding. The children with SLI showed specific difficulties in the omission of whole words (e.g. auxiliary verbs and subject nouns) and omissions of grammatical morphology (e.g. past tense—*ed*) reflecting the difficulties shown in their oral language. Receptive grammar made a significant contribution to writing complexity and accuracy. Phonological fluency contributed to writing productivity, such as the production of diverse vocabulary, ideas and content and writing fluency. Phonological STM and word reading explained additional variance in writing accuracy over and above the SLI group's oral language skills.

C. J. Mackie (✉)
Division of Psychological Medicine and Psychiatry, Addictions Department, Institute of Psychiatry, KCL, 4 Windsor Walk, London SE5 8AF, UK
e-mail: clare.mackie@kcl.ac.uk

J. Dockrell
Psychology and Human Development Department, Institute of Education, University of London, London, UK

G. Lindsay
Centre for Development, Appraisal and Education, University of Warwick, Coventry, UK

Keywords Writing development · Specific language impairment · Oral language

Introduction

Children with specific language impairment (SLI) demonstrate significant difficulties in the production of written text (Bishop & Clarkson, 2003; Dockrell, Lindsay, Connelly, & Mackie, 2007; Fey, Catts, Proctor-Williams, Tomblin, & Zhang, 2004; Gillam & Johnston, 1992; Mackie & Dockrell, 2004; Scott & Windsor, 2000; Windsor, Scott, & Street, 2000). The written texts produced by children with SLI are characterised by fewer words and less complex sentences; they also contain a greater proportion of spelling errors and are less lexically diverse (Fey et al., 2004; Mackie & Dockrell, 2004; Scott & Windsor, 2000), with the most significant difficulties in written grammatical acceptability (Gillam & Johnston, 1992; Fey et al., 2004; Mackie & Dockrell, 2004; Scott & Windsor, 2000; Windsor et al., 2000). Given these difficulties, it is surprising that our knowledge of how the children's oral language difficulties contribute to their writing is limited. Furthermore, little research exists examining how reading and phonological short-term memory (STM) might further explain their writing difficulties.

The written texts of children with SLI are commonly assessed in comparison to children matched according to age and language only. Recently research has highlighted the role of reading in oral language competence, suggesting that reading skills can support both oral language and indirectly writing proficiency. Models of writing have highlighted three dimensions of writing: productivity, complexity and accuracy in children's writing (Puranik et al., 2008; Wagner et al., 2010). These three dimensions of writing have yet to be demonstrated in the written texts of children with SLI. A detailed analysis of the factors which limit children's text production would allow for the formulation of evidence based interventions (Graham, 2006; Fey et al., 2004) and for the implementation of empirically-based intervention strategies that can target their needs.

Much of our understanding of how we compose and produce written text stems from the work by Hayes and Flower (1986). Three recursive cognitive processes of writing: translation, planning and reviewing were suggested to interact with the constraints of memory and task environment. However, models of skilled writing fail to account for how children learn to write (Berninger, 1999). Young children's writing tends to be focused at the translation stage which includes text generation (i.e. idea and content generation) and transcription (i.e. spelling and handwriting; Bereiter & Scardamalia, 1987; Berninger, 1999).

Text generation shares many components with oral language, such as retrieval of vocabulary and sentence construction. However, models of writing do not identify oral language as central to the writing process. There is evidence suggesting that oral language and verbal reasoning contributes to compositional quality in children's writing (Abbott & Berninger, 1993; Berninger & Whitaker 1993). Poor oral language skills are associated with poor fluency in the production of words and sentence clauses (Berninger & Fuller, 1992) and poor written text performance (Cragg & Nation, 2006). Examining the contribution of good and poor oral language skills to writing development can allow for the examination of mechanisms underlying writing skill.

Writing productivity, complexity and accuracy in children with SLI compared to children matched for age, language and reading ability

SLI is a developmental disorder characterised by difficulties in the acquisition and the processing of oral language (see Bishop, 1997 and Leonard, 1998 for further information). The children's problems involve particular difficulties with the subcomponents of the language system which include phonological processing, lexical retrieval, syntactic comprehension, and production, and in the production of certain inflectional morphemes, such as the past tense—*ed* inflection. Given the contribution of oral language to writing in typically developing children, there are reasons to suggest that children with SLI will develop problems with writing, and there are a range of studies which demonstrate this.

Compared to children of a similar chronological age (CA), children with SLI show significant difficulties in writing *productivity*, as measured by the total number of words, lexical diversity, writing fluency and content (e.g. Gillam & Johnston, 1992; Fey et al., 2004; Mackie & Dockrell, 2004; Scott & Windsor, 2000) and writing *complexity*, as measured by the percentage of complex sentences (e.g. Gillam & Johnston, 1992; Fey et al., 2004; Mackie & Dockrell, 2004; Puranik et al., 2007; Scott & Windsor, 2000), but are commensurate with children of a similar language ability (LA), suggesting that these difficulties are related to the level of the language experience of the SLI group. Children with SLI have exhibit significant problems in the *accuracy* of written texts, as measured by the proportion of spelling errors (Bishop & Clarkson, 2003; Mackie & Dockrell, 2004), grammatical errors such as the omission of auxiliary and copula forms of *be* (e.g. omissions of *is*, *are* and *were*) and the omission of inflectional morphemes such as the past tense—*ed* and plural noun errors (Mackie & Dockrell, 2004; Windsor et al., 2000). These errors are shown to be more frequent in the written texts of children with SLI than CA and LA matched peers, suggesting areas of specific difficulty for children with SLI.

One previous study has compared the writing of children with language learning impairment (LLI) with children matched for age, language and reading (Gillam & Johnston, 1992). Children with LLI were identified based on similar criteria as children with SLI: a discrepancy existed between their nonverbal abilities and spoken language based on standardised tests (Gillam & Johnston, 1992). Results showed that the LLI group attempted to produce a similar proportion of complex sentences as children matched for age and language. However, the LLI group's written narrative contained a greater proportion of grammatical errors within the complex sentences. Once the authors excluded from the analysis complex sentences that contained grammatical errors, the LLI group produced fewer correct complex sentences compared with children matched for age and language, but the same percentage as children matched for reading. Initially, it would appear that children with LLI were performing at a level matched by their reading ability peers, but if their grammatical errors were forgiven the LLI group were evidencing a more 'mature' profile than the reading matched group, suggesting that reading might not be as important for writing complexity. However, to our knowledge, no study has compared children with SLI with children matched for reading on measures of writing productivity (e.g. text length and lexical diversity), and accuracy (e.g. spelling).

Writing components: productivity, complexity and accuracy in children with SLI

Previous studies have explored the underlying structure of writing using an analysis of fine grained writing variables (Puranik et al., 2008; Wagner et al., 2010). In 120 children aged between 8 and 11 years, Puranik et al. (2008) performed a principal components analysis demonstrating that writing measures commonly used by researchers could be categorised into three dimensions: productivity (i.e. text length, lexical diversity) complexity (i.e. percentage of complex sentences) and accuracy (i.e. grammatical and spelling errors). This preliminary research allowed Wagner et al. (2010) to examine alternative models of the structure of writing in 186 children aged between 6 and 9. The presence of three writing factors identified by Puranik et al. (2008) productivity, complexity and accuracy were replicated, along with two additional writing factors, macro-organisation and writing fluency, suggesting that multilevel writing measures are able to capture variation in writing. While there is growing information about the dimensions of writing in typically developing children, relatively little is know about children with SLI. This is noteworthy as children with specific difficulties in writing might demonstrate different development patterns. To understand individual differences in writing, it is therefore essential to examine whether these components of writing replicate in children who show difficulties in the production of written text.

Furthermore, we now know that children with SLI show specific problems in writing, we do not know how the children's oral language deficits and associated problems such as reading might contribute to their writing difficulties.

The role of oral language, reading and phonological STM in the productivity, complexity and accuracy of writing

There are reasons to predict that the specific deficits in oral language of children with SLI will impact on writing in a number of ways. In terms of the *productivity* of writing, limited vocabulary knowledge might lead to written texts reduced in length. More advanced writing is associated with the greater use of adjectives and adverbs (Beard, 2000; Perera, 1984). Thus, strength in vocabulary knowledge might support the efficient retrieval of words to use in written texts and provide a variety of lexical items on which to draw, aiding written content.

The grammatical *complexity* of children's writing might be influenced by their syntactic skills (van der Lely & Christian, 2000), manifesting themselves through the construction of simple rather than complex sentences. Children with SLI often have difficulties acquiring inflectional morphemes representing tense and agreement in the underlying structure of syntactic sentences (Rice & Oetting, 1993), reflecting written texts which contain fewer morphological structures. In terms of the *accuracy* of written text, the children's difficulties with syntax might be reflected in the omission of inflectional morphemes (e.g. Mackie & Dockrell, 2004; Windsor et al., 2000) and words containing syntactic structures such as verbs (Windsor et al., 2000). A large proportion of children with SLI experience phonological difficulties, which may directly contribute to an increased number of spelling errors (Bishop & Clarkson, 2003; Zourou, Ecalle, Maynan, & Sanchez, 2010).

Given the range of problems shown in oral language, it is not surprising that children with SLI demonstrate difficulties in reading (Bishop & Snowling, 2004). Poor phonological skills can contribute to difficulties translating orthography to phonology resulting in problems with reading decoding (Muter, Hulme, Snowling, & Stevenson, 2004). Reading decoding is a strong predictor of conventional spelling, where a child approaches the consistent rules of orthography, but not necessarily of phonological spelling ability (Caravolas, Hulme, & Snowling, 2001), suggesting that reading decoding skill provides support for orthographic knowledge in *accurate* spelling development. Successful text reading can also provide information on written *productivity*, through the organisation of written text and ideas for written content, along with sentence *complexity* and grammar (Berninger et al., 2006).

Writing involves a number of inter-related processes creating significant demands on an individual's working memory capacity (Kellogg, 2001; Torrance & Galbraith, 2006). Research has suggested that transcription (e.g. spelling and handwriting) demands a substantial amount of working memory resources in children allowing for few available resources for sentence construction and content generation (Bourdin & Fayol, 1994; Graham, Berninger, Abbott, Abbott, & Whitaker, 1997), leading to the suggestion that working memory limitations underlie children's failure to engage in text generation processes during writing due to the competing demand from transcription processes (McCutchen, 2000). An increase in grammatical errors, (e.g. subject-verb agreement) has been shown when children are asked to perform a secondary task, such as serial recall while writing, or when asked to produce sentences with a greater number of prepositional clauses (Fayol, Hupet, & Largy, 1999; Negro, Chanquoy, Fayol, & Louis-Sidney, 2005), suggesting that the division of attention between writing and the secondary task forced a reduction in writing *accuracy*.

A general limitation in processing capacity (Montgomery & Windsor, 2007) and/or speed of processing (Miller, Kail, Leonard, & Tomblin, 2001) has been proposed as a possible theoretical explanation of SLI. A prominent explanation has focused on deficits in phonological short term memory (STM; Gathercole & Baddeley, 1990; Conti-Ramsden, 2003), which is hypothesized to delay language learning and the ability to comprehend syntax. Phonological STM is often measured by nonword repetition in which children repeat nonwords of increasing length, a task argued to be highly sensitive to both phonological storage capacity and the ability to deal with processing stimuli presented at fast rates and increasing lengths (Gathercole, 2006). A combination of a possible limitation in working memory capacity and the competing tasks of the writing process might lead to greater difficulties in writing *accuracy* and an elevated error rate in children with SLI.

The current study

Given the previously reviewed evidence, it can be suggested that the oral language deficits of children with SLI will play a direct role in all three writing components. Therefore, the role of oral language was considered of primary theoretical interest. Due to the complex nature of the writing task and evidence suggesting that children with SLI have deficits in phonological STM, it can be suggested that phonological STM may contribute to an increase in writing errors over and above what would be expected solely due their oral language deficits. Word reading was examined last given the large associations demonstrated between reading and writing (Fitzgerald & Shanahan, 2000).

Two previous studies by our research team have examined the contribution of oral language and reading to a single global score of writing competence in children with SLI (Dockrell, Lindsay, Palikara, & Cullen, 2007; Dockrell et al., 2009). Vocabulary and word reading were found to be the strongest predictors of overall writing ability at ages 11 and 16. The current study differs from previous work by examining the unique contribution of oral language, reading and phonological STM to three writing components as defined by a fine grained analysis of children's written texts.

Our first research question examined whether the productivity, complexity and accuracy of the written texts of children with SLI differs in comparison to three separate groups of children matched for (1) chronological age, (2) receptive vocabulary, and (3) reading decoding. Receptive vocabulary was chosen as a comparative measure due to the following reasons; firstly, vocabulary was shown to explain variability in a standardized measure of writing (Dockrell, Lindsay, Palikara, & Cullen, 2007), secondly, vocabulary was proposed to support both the retrieval and production of complex vocabulary, which in turns allows the communication of ideas and content in written texts. Thirdly, vocabulary is associated with reading proficiency which is known to support writing in a variety of ways.

Our second research question examined whether the variables chosen for the writing analysis reflected the complex nature of writing and whether they adequately represented both typically and atypically developing children's writing. A principal components analysis was performed to summarise patterns of correlations among the observed variables to a smaller number of components and to examine whether the three components of writing (productivity, complexity, accuracy) observed in typically developing children's writing (Puranik et al., 2008; Wagner et al., 2010) can be replicated in children with SLI. This would provide a better understanding of individual differences in models of writing development allowing for tailored intervention programs.

Our third research question examined the extent to which oral language, reading and phonological STM accounted for unique variance in the productivity, complexity and accuracy of writing in the SLI group. With respect to oral language, it was proposed that poor receptive vocabulary would impact on a range of writing dimensions including text length, content, lexical diversity and vocabulary frequency. Poor receptive grammar would lead to fewer complex sentences, and more grammatical errors. Difficulties in phonological awareness and fluency would translate into spelling errors and poor productivity. As the generation of written text shares many components with oral language, such as retrieval of vocabulary and grammatical sentence construction, we considered oral receptive vocabulary first and receptive grammar second to be of primary theoretical importance in the contribution to written text performance. Therefore, the contribution of receptive vocabulary and grammar would be considered prior to phonological awareness and fluency.

Given that the previously reviewed literature suggests that the production of written text can place demands on storage capacity resulting in a greater number of errors (e.g. Torrance & Galbraith, 2006), we expected phonological STM to be related to the accuracy of written text. Difficulties in holding phonological information in memory and processing this information efficiently would lead to more omissions of words, inflectional morphemes and spelling errors. Finally, given the previously reviewed literature, it can be suggested that word reading would impact on spelling accuracy.

Methods

Participants

Forty-six children (mean age 10:8, SD = 3 months; 35 boys and 11 girls) with SLI from two English local authorities participated in the current study. Participants were identified following a survey of educational provision for children with developmental language difficulties in two local authorities (LAs) in England. Speech and language therapists, educational (school) psychologists and special educational needs co-ordinators identified children between 7 and 8 years (mean age 8 years 3 months) who had a discrepancy between their speech and language functioning and that which would be expected given the child's functioning in other areas, and who were experiencing significant language-based learning needs (Dockrell & Lindsay, 1998). The aim was for a representative sample of the original professional referrals but excluding children with other complicating factors such as a diagnosis of autism, sensory impairments or genetic disorders. In addition, children were excluded where English was an additional language. Parental consent was secured and 59 children agreed to participate. In order to capture the range of skills represented by children at mainstream schools the 13 children attending special schools for language and communication difficulties were excluded from the current sample. Individual assessments were conducted to confirm a discrepancy between nonverbal ability and oral language measures. Repeated measures ANOVAs confirmed that vocabulary (British Picture Vocabulary Scale Mean Z score $= -1.09$; SD $= .61$), and receptive grammar (Test of Receptive Grammar Mean Z score $= -1.48$, SD $= .90$) were significantly below the participants' nonverbal ability (British Ability Scales Matrices Mean Z score $= -.69$, SD $= .91$) Wilks's Lambda $= 60$, $F(2, 45) = 14.58$, $p = .001$ (See Dockrell & Lindsay, 1998 and Dockrell, Lindsay, Palikara, & Cullen, 2007 for further information on participant recruitment and identification).

All children were followed up approximately 2 years later when they reached 10–11 years of age. Forty-one children attended mainstream schools and the remaining five attended mainstream schools with special provision for children with SLI. Parental consent and assent by each child were also obtained at the recruitment and follow-up stage.

In addition to the SLI group, three additional groups were identified. A Chronological Age matched group (CA group, $N = 42$; Mean age 11 years, SD = 3 months), a group who were matched according to receptive vocabulary on the British Picture Vocabulary Scale (BPVS; Dunn, Dunn, Whetton, & Burley, 1997: Language Age (LA) group, $N = 46$; Mean age 8:5, SD = 12 months) and a group who were matched according to reading decoding on the British Ability Scales (BAS) word reading subscale (BAS; Elliott, Smith, & McCulloch, 1997: Reading Age (RA) group, $N = 46$; Mean age 7:8, SD = 4 months). As expected from the matching criteria there were no group differences on the raw score of the BPVS between the SLI and LA group (SLI: $M = 83.39$, SD = 13.36; LA: $M = 83.33$, SD = 13.39, t (91) = .02, $p = .98$) or between the SLI and RA group on the raw score of the BAS Word Reading (SLI: $M = 103.26$, SD = 28.63, RA: $M = 100.02$, SD = 30.36, t (91) = .53, $p = .60$). The LA group scored higher on the BPVS than the RA group (RA: $M = 77.71$, SD = 16.75), but the difference failed to reach statistical significance, t (90) = 01.77, $p = .08$. The LA group did score significantly higher than the RA group in BAS Word Reading (LA: $M = 115.76$, SD = 31.68, t (90) = 2.01, $p = .04$).

Each comparison child attended the same school as the children in the SLI group, ensuring for comparability in educational instruction in writing. All comparison children were performing within the average range on classroom activities, as reported by the children's class teacher.

Measures and procedure

The measures consisted of a narrative writing sample, standardised measures of oral language, reading, nonverbal ability and phonological STM. All assessments took place individually at the child's school and were split into two separate sessions each lasting approximately 45 min.

Narrative writing

Each child wrote a narrative story in response to a sequence of six pictures contained within a wordless story book. The sequence of pictures outlined a story which comprised an initiating event, an action sequence involving a number of different characters and a resolution. A picture prompt allowed for easier lexical retrieval, and for inferences to be made concerning events and characterisation. As the assessor was present throughout the procedure, it was possible to interpret misspellings accurately by noting what the child was saying as they wrote and by asking what a particular word or sentence represented immediately after it was written. There was no time restriction for the completion of the written text, although the time in minutes and seconds from when each participant began writing and ended was noted.

Oral language

Four variables assessed oral language

1. *Receptive vocabulary* The British Picture Vocabulary Scale (BPVS: Dunn et al., 1997) assessed receptive vocabulary. Participants are asked to point to the picture that best illustrates a word spoken by the assessor. Cronbach's alpha ranges from .89 to .91 for 10–12 year olds.
2. *Receptive grammar* The Test of Reception of Grammar (TROG: Bishop, 1989) assessed the understanding of grammatical constructions. The TROG involves the presentation of four pictures and participants are asked to select the picture that matches the sentence that the assessor reads out loud. For 10–12 year olds, test–retest coefficients range from .65 to .85.
3. *Phonological awareness* Three measures (rhyme, alliteration and spoonerisms) from the Phonological Assessment Battery (PhAB: Frederickson, Frith, & Reason, 1997) measured phonological awareness. For the *rhyme* subtest the child is asked to identify two words out of a choice of three that rhyme with each other. Cronbach's alpha ranges from .85 to .97. For *alliteration*, the child is asked which two of three words begin with the same sound. Cronbach's alpha ranges from .85 to .95. Spoonerisms involve transposing onsets of initial syllables, e.g. Chuck Berry to Buck Cherry. Cronbach's alpha ranges from .82 to .96.
4. *Phonological fluency* Three measures of fluency (semantic, alliteration and rhyme) from the PhAB measured phonological fluency. The child is asked to say as many words of a specified type (e.g. animals) for semantic fluency, words that begin with a letter 'm' for alliteration fluency and words that sound like 'whip' or 'more' for rhyme fluency, within a time limit of 60 s in each case. For all subtests Cronbach's alpha was found to be above .80.

Nonverbal ability

The British Ability Scales II (BAS II) matrices subtest (Elliott et al., 1997) assessed nonverbal ability. Participants are asked to point to the missing pattern out of a choice of six responses. Test–retest reliability coefficients ranged from .88 to .90 for the relevant age range of this sample (10–12 year olds).

Reading

The BAS-II word reading subset assessed single word reading. This subtest requires participants to read out loud single written words. Test–retest reliability coefficients for age 10–12 ranged from .95 to .97.

Phonological short-term memory

The Children's Nonword Repetition task (CNRep: Gathercole & Baddeley, 1996) assessed phonological short-term memory. The researcher says a nonword (e.g. barrazon) and the child is asked to repeat each word exactly. The entire test consists of 40 multi-syllabic nonsense words, ten each containing one, two, three, or four syllables. The nonword repetition paradigm requires temporary storage of an unfamiliar phonological sequence. Scores on the nonword repetition test are closely associated with measures of short-term memory such as digit span. Test–retest reliability was .77.

Writing analysis: transcription, coding and reliability

Transcription

All written texts were transcribed and entered in a standard format using the Systematic Analysis of Language Transcript conventions (SALT: Miller & Chapman, 2000). The analysis of the children's written text focused on the productivity of text production, its complexity and its accuracy (Puranik et al., 2008).

Coding

Five variables were coded that represented productivity.

1. *The Total Number of written Words (TNW)*
2. *The number of Words per Minute (WpM)* assessed writing fluency. The total number of words was divided by the time taken to produce the written text.
3. *The Number of Different words (NDW)* assessed lexical diversity. In order to reduce the effects of text length, we constrained the assessment to the first 25 words written.
4. *Vocabulary frequency* was assessed by comparing the vocabulary contained in each written story with a basic vocabulary list for children aged 6–12 (Graham, Harris, & Loynachan, 1993). A word not included on this list was judged not to be frequent.
5. *Content* Written texts were examined for the inclusion of an initiating event, an action sequence and a story resolution following a procedure developed by Stein and Glenn (1982) and adapted by Reilly, Losh, Bellugi & Wulfeck (2004). Two points were awarded for a complete initiating event (e.g. frogs were living by the pond and flew to a town) and a story resolution (e.g. frogs disappear and the dog finds the leaves), with one point for a partial story component. Four points were awarded for complete action sequences. An example of an action sequence depicted by a picture represented a dog chasing a frog. A single point was awarded if the action sequence 'chasing' and the two characters of the story 'dog' and 'frog' were mentioned.

Three variables were coded that represented complexity

1. *Main clauses* The total number of main clauses each child produced was counted. A main clause was defined as a sentence or unit that contains a single unified predicate, i.e. a sentence that expresses a single situation, an activity, event or state (Berman & Slobin, 1994), e.g. *he stopped running*.
2. *Coordinating clauses* The total number of coordinating clauses was counted. A coordinating clause was categorised as two main clauses was a coordinating conjunction, e.g. *the boy went home and fell asleep*.
3. *Words per Clause (WpC)* The total number of clauses each child produced was divided by the total number of words written.
4. The total number of words that contained *derivational morphemes* was divided by the total number of words to provide a proportionate score. Derivational morphemes were categorised into prefixes and suffixes. Prefixation is the addition of a prefix in front of a base, for example, *re/cycle* and *dis/appear*. Suffixation is the addition of a suffix at the end of a base, for example, *age/ism* and *marginal/ise*.

Three variables were coded that represented accuracy

1. *Total number of spelling errors* Each spelling was classified as correct/incorrect. Following a scoring scheme by Bruck, Treiman, Caravolas, Genesee, and Cassar (1998) each incorrect spelling was categorised as phonologically accurate/inaccurate or orthographically accurate/inaccurate, thus receiving two ratings. A Phonological accurate error was defined when it could be pronounced like the target word, e.g. *bak instead of back*. A phonological inaccurate error was defined as not having a possible sound to grapheme correspondence, e.g. *clars* instead of *clouds*. An orthographic accurate error was defined as a word with a permissible sequence in English, e.g. always instead of always. A spelling in which the sequence of letters would not be permissible in English, e.g. *wusz* instead of *once* was defined as an orthographically inaccurate error. Words that were spelt correctly but not correct in the context of the sentence (e.g. *is/are* or *was/were*) were not included as spelling errors. Children with SLI often produce substitution of words in their oral language in particular auxiliary verb errors (Rice & Wexler, 1996; Leonard et al., 1997, 2003). Such errors were considered separately to spelling errors.
2. *Omission of whole words* A word that was obligatory given the context (e.g. the [*frog*] followed the dog) was classified as omitted. The types of omission errors (i.e. subject nouns, auxiliary verbs, and prepositions) were investigated and divided by the total number of obligatory contexts for that particular word to provide a proportionate score. An obligatory context was defined as the total number of correct occasions of use plus the number of occasions on which the obligatory word was omitted. For example, if a child produced an auxiliary verb correctly on 10 different occasions, but also omitted an auxiliary verb on five different occasions in which it was considered obligatory then the score for obligatory contexts would be 15. Thus a child would have omitted auxiliary verbs on one third (5/15 = .33) of the occasions in which it was required.

3. *Omissions of inflectional morphemes* Omissions of plural noun—*s*, progressive—*ing*, and past tense—*ed*, were counted and divided by its obligatory context to provide a proportionate score.

Reliability

Inter-rater reliability checks were performed on a randomly selected subset of 18 written texts (10 % of all written texts) by the first author and a postgraduate researcher. The following are reliability estimates for each writing measure: TNW, 100 %; NDW, 95 %, content total score, 95 %, derivational morphemes 95 %, spelling errors, 100 %; main clauses, 98 %; coordinating clauses, 97 %; omissions of inflectional morphemes, 98 %; and omission of whole words, 95 %. In case of disagreement the first author's scores were counted in the main analyses.

Statistical analysis

Statistical analyses were conducted using STATA 10.0 (StataCorp, 2003). In order to compare the language and literacy scores, which present on different distributions, the raw scores were first converted into a percentile rank and then a standard *Z* score. A mean of 0 indicates an average score across a normal distribution and a negative score indicates a score that is below average.

Research question 1: do measures of writing productivity, complexity and accuracy in the SLI group differ compared to the CA, LA and RA groups?

Group differences in the writing measures were analysed using a multivariate analysis of variance (MANOVA) with group as the between-subjects factor. Univariate ANOVAs were performed for each measure of writing, a Bonferroni correction was applied to adjust for Type I error. For each statistically significant univariate ANOVA, Bonferroni post hoc tests were conducted to compare the performance between groups. Effect sizes are reported using eta-squared (η^2).

Research question 2: do the three writing components: productivity, complexity and accuracy replicate in the SLI group?

A principal component analysis was performed. To assist with the interpretation of results promax rotation with Kaiser normalisation was used. Promax rotation is an oblique rotation allowing factors to be intercorrelated. The criterion used to select the number of factors was an eigenvalue greater than 1. To guide item selection we followed recommendations by Brown (2006). Items were not allowed to cross-load (i.e. load >.40 on more than one factor), have small loadings on all factors (<.40), and each item had to load with more than one other item on a factor.

Research question 3: what is the relative contribution of nonverbal ability, oral language, reading and phonological STM to the three writing components in children with SLI?

Hierarchical regression analysis was performed. Nonverbal ability was controlled for and entered first into each model. Receptive oral language measures (vocabulary and grammar) were entered prior to expressive oral language measures (phonological awareness and fluency). Phonological STM was entered in the sixth step. Word reading was entered last given the large associations demonstrated between reading and writing (Fitzgerald & Shanahan, 2000).

The purpose of these analyses was to examine the strength of the association between oral language measures and writing components and to determine whether phonological STM and word reading contributed any additional variance over and above the variance accounted for by oral language.

Results

Raw score and Z score means for the oral language variables for the SLI group are shown in Table 1.

Research question 1: do measures of writing productivity, complexity and accuracy in the SLI group differ compared to the CA, LA and RA groups?

Table 2 presents means and standard deviations for all writing variables across the four groups. The multivariate main effect of group was revealed to be significant, Wilks's Lambda = .007, $F(12,160) = 3.57$, $p < .001$. Follow-up univariate ANOVAs revealed significant group differences on all writing measures, $F(3,160) > 4.41$, $p < .01$ in all cases, with group differences explaining between 1 and 22 % of the variance in the writing measures. Bonferroni pairwise comparisons were performed for all measures and the results of these comparisons

Table 1 Raw score, Z score means (M) and standard deviations (SD) for language and literacy measures for the SLI group

Language and literacy variables	Raw score M (SD)	Z score M (SD)
BPVS	83.39 (13.16)	−1.12 (.76)
Trog	14.39 (2.76)	−1.16 (1.13)
BAS matrices	91.35 (17.39)	−.53 (.97)
Phonological awareness composite	31.80 (14.95)	–
Phonological fluency composite	35.00 (9.48)	–
BAS word reading	100.02 (30.36)	−1.41 (.93)
CNREP	9.06 (5.77)	−1.92 (1.01)

Dashes indicate that Z scores were not available for composite cores in phonological awareness and fluency are shown by the superscripts accompanying the means displayed in Table 2. The SLI group were significantly different relative to the CA group on all measures, with differences on 3/12 comparisons with the LA group (word frequency, whole word and inflectional morpheme omissions) and 2/12 compared with the RA group (both types of omissions). A more detailed analysis of spelling and grammatical errors was performed.

Spelling and grammatical accuracy

The statistical design paralleled that used in the previous analysis, i.e. MANOVA, followed by univariate ANOVAs. Table 3 presents the means and standard deviations for errors in spelling and grammar. The multivariate effect of group was significant, Wilks's Lambda = .32, $F(8,180) = 3.87$, $p < .001$. Follow-up univariate ANOVAs showed significant group differences on all writing measures with the exception of omissions of prepositions, $F(3,180) > 3.18$, $p < .01$, with 5–12 % of the variance accounted for by group differences. As indicated by the superscript letters accompanying the means in Table 3, the SLI group produced significantly more errors relative to the CA group on 7/8 measures, but significantly more errors

Table 2 Means (*M*) and standard deviations (SD) of writing measures by the SLI, CA, LA, and RA groups

Writing measures	Group				F	η^2
	SLI *M* (SD)	CA *M* (SD)	LA *M* (SD)	RA *M* (SD)		
Total number of words	62.93 (33.01)[a]	99.40 (41.27)[ab]	79.24 (65.50)	64.23 (33.93)[b]	5.85*	.10
Words per minute	8.23 (3.10)[a]	11.53 (3.90)[abc]	7.65 (4.05)[b]	8.25 (6.88)[c]	5.91*	.02
Number of different words	18.93 (2.74)[a]	21.31 (1.92)[abc]	19.14 (2.88)[b]	19.48 (3.60)[c]	6.12*	.10
Word frequency	5.48 (3.30)[ab]	7.88 (2.97)[a]	7.79 (3.93)[b]	6.93 (3.02)	4.54*	.08
Content	5.13 (1.91)[a]	6.33 (1.41)[ab]	5.29 (1.98)	5.08 (1.93)[b]	4.41*	.01
Words per clause	8.45 (2.19)[a]	11.11 (1.95)[abc]	9.36 (2.59)[b]	8.91 (2.52)[c]	10.36**	.16
Main clauses	.75 (.24)[a]	.41 (.19)[abc]	.64 (.28)[b]	.69 (.24)[c]	16.21**	.22
% coordinated clauses	.18 (.19)[a]	.41 (.21)[abc]	.24 (.24)[b]	.22 (.21)[c]	9.07**	.13
% spelling errors	.16 (.12)[a]	.04 (.03)[abc]	.10 (.10)[b]	.15 (.13)[c]	11.13**	.17
% omission errors	.03 (.05)[abc]	.01 (.01)[a]	.01 (.02)[b]	.01 (.02)[c]	6.07*	.10
% inflectional morpheme errors	.07 (.07)[abc]	.01 (.01)[a]	.02 (.04)[b]	.02 (.04)[c]	12.19**	.19
% derivational morphemes	.02 (.02)[a]	.03 (.02)[ab]	.02 (.02)	.02 (.02)[b]	4.86*	.09

SLI specific language impairment, *CA* chronological age, *LA* language age, *RA* reading age

All F scores corrected for multiple comparisons with a bonferroni correction of $p = .004$

** $p < .001$; * $p < .004$

Values sharing the same superscript (i.e. a, b, or c) are significantly different from each other at $p < .05$

on only 3/8 measures compared to the LA group (orthographic spelling, subject noun, and past tense—*ed* omissions), and 3/8 measures compared to the RA group (subject nouns, past tense—*ed* and auxiliary verb omissions).

Research question 2: do the three writing components: productivity, complexity and accuracy replicate in the SLI group?

Prior to performing the principal component analysis (PCA) the results from the RA and LA groups were combined due to similar age ranges. The CA group was excluded from the following analysis due to low prevalence of errors in items of grammatical and spelling accuracy. Table 4 presents bivariate correlations among the writing measures for the SLI group above the diagonal and for the combined LA/RA comparison group below the diagonal. These results highlight two main findings. Firstly, the proportion of derivational morphemes demonstrated moderate associations with word frequency, words per clause and the proportion of spelling errors in the comparison groups, but not in the SLI group. Secondly, moderate associations were demonstrated between measures of accuracy (i.e. spelling and omission errors), and measures of writing productivity, and complexity in the comparison groups, which were not observed in the SLI group.

A PCA including all writing measures in Table 2 was performed separately for the SLI group and the combined LA and RA samples. The Total Number of Words was excluded given the strength of its relationship to the remaining writing measures.

Table 3 Mean (*M*) and standard deviations (SD) of spelling errors, whole word and inflectional morpheme omissions by the SLI, CA, LA, and RA groups

Writing measures	Group				F	η^2
	SLI *M* (SD)	CA *M* (SD)	LA *M* (SD)	RA *M* (SD)		
Spelling errors						
Phonological inaccurate	.59 (.35)[a]	.36 (.37)[a]	.43 (.31)	.45 (.35)	3.44*	.06
Orthographic Inaccurate	.07 (.13)[ab]	.01 (.04)[a]	.02 (.05)[b]	.03 (.09)	4.56*	.07
Whole word omissions						
Subject noun	.08 (.18)[abc]	.01 (.02)[a]	.01 (.03)[b]	.01 (.03)[c]	6.57**	.10
Auxiliary verbs	.16 (.30)[ab]	.02 (.06)[a]	.07 (.18)	.02 (.06)[b]	5.62*	.09
Prepositions	.04 (.15)	.01 (.02)	.05 (.17)	.04 (.12)	.87	.01
Inflectional morpheme omissions						
Noun plural	.03 (.01)[a]	.01 (.02)[a]	.02 (.05)	.02 (.04)	3.18*	.05
Past tense—ed	.22 (.01)[abc]	.01 (.03)[a]	.03 (.13)[b]	.03 (.22)[c]	7.74**	.12
Progressive—ing	.09 (.23)[a]	.01 (.01)[a]	.01 (.05)	.03 (.16)	3.24*	.05

SLI specific language impairment, *CA* chronological age, *LA* language age, *RA* reading age

All F scores corrected for multiple comparisons with a bonferroni correction of $p = .006$

** $p < .001$; * $p < .006$

Values sharing the same superscript (i.e. a, b, c) are significantly different from each other at $p < .05$

Table 4 Intercorrelations between writing measures for the LA and RA combined group are below the diagonal and for the SLI group above the diagonal

	1	2	3	4	5	6	7	8	9	10
1. Words per minute	–	.42	.46	.44	.42	−.33	.22	−.30	−.29	.09
2. Number of different words	.18	–	.21	.45	.40	−.41	.29	−.30	−.30	.32
3. Word frequency	.25	.29	–	.50	.27	−.29	.20	−.18	−.17	−.04
4. Content	.29	.29	.50	–	.33	−.48	.40	.02	−.37	.07
5. Words per clause	.30	.40	.44	.32	–	−.60	.43	−.28	−.29	.08
6. Main clauses	−.20	−.31	−.31	−.27	−.65	–	−.82	.17	.35	−.12
7. % coordinated clauses	.16	−.26	.29	.36	.48	−.72	–	.03	−.23	.12
8. % spelling errors	−.32	−.29	−.22	−.35	−.47	.27	−.19	–	.30	−.20
9. % omission errors	−.12	−.19	−.10	−.03	−.24	−.10	.03	.29	–	−.25
10. % derivational morphemes	.24	.22	.43	.27	.36	−.25	.24	−.32	−.15	–

Values greater than .29 are significant at the Bonferroni corrected level $p = .005$ for the LA and RA combined group and .41 for the SLI group

The proportion of whole word and inflectional morpheme errors were combined to provide an overall measure of the proportion of omission errors due to the low frequency of errors in the comparison groups

For the SLI group, the PCA resulted in three components with eigenvalues >1, accounting for 68 % of the variance across these measures (see Table 5). The three components represented three constructs of writing. All measures of complexity loaded on to the first component. Measures of productivity (content, word frequency, number of different words) and fluency (words per minute) loaded on to the second component, and measures of accuracy, the proportion of spelling, omission errors and the proportion of derivational morphemes, loaded on to the final factor.

Table 5 Principal component analysis for the SLI group ($N = 46$)

Writing measures	Component scores		
	1. Complexity	2. Productivity	3. Accuracy
Words per clause	**.45**	.28	.19
% main clauses	**−.88**	−.07	−.05
% coordinated clauses	**.98**	−.10	−.11
Words per minute	−.10	**.79**	.17
Number of different words	.19	**.50**	.26
Word frequency	−.01	**.88**	−.15
Content	.31	**.65**	−.14
% of spelling errors	−.33	−.22	**−.88**
% of omission errors	−.24	−.13	**−.50**
% of derivational morphemes	.14	−.32	**.71**

Table 6 Principal component analysis for the LA and RA groups ($N = 92$)

Writing measures	Component scores		
	1. Complexity	2. Accuracy	3. Productivity
Words per clause	**.66**	.37	.00
% main clauses	**−.98**	.06	.13
% coordinated clauses	**.87**	−.22	−.11
% of spelling errors	−.05	**−.82**	.10
% of omission errors	.06	**−.75**	.14
Words per minute	−.16	**.42**	.29
% derivational morphemes	.03	**.40**	.36
Content	−.09	−.09	**.87**
Word frequency	.09	−.06	**.80**
Number of different words	.24	.21	**.41**

For the combined LA/RA group, the PCA also resulted in three components with eigenvalues >1, accounting for 60 % of the variance across these measures (see Table 6). Similar to the SLI group, the first component reflected writing complexity. The proportion of spelling, omission errors, and derivational morphemes loading highly on to the second component reflecting written accuracy, but in contrast to the SLI group, fluency (words per minute) was associated with accuracy of writing rather than productivity, highlighting the association between fluency, and error production in younger children's writing. The final component reflected measures of written productivity (content, word frequency, and number of different words).

Research question 3: what is the relative contribution of nonverbal ability, oral language, reading and phonological STM to the three writing components in children with SLI?

Three hierarchical regression analyses were conducted for each of the three writing component scores for the SLI group as developed by the previous PCA analysis. Table 7 provides regression parameter estimates for the full model (i.e. including all covariates) and *R*-square statistics are provided for each predictor as they are entered into the model. For writing complexity, nonverbal ability explained 18 % ($p = .002$) of the variance and receptive grammar increased the variance explained by a further 6 % ($p = .03$); no other measures made a significant contribution to the model ($R^2 = .24$). For writing productivity, nonverbal ability accounted for 6 % of the variance, receptive grammar and phonological awareness increased the variance explained by a significant 12 % ($p = .005$) and 8 % ($p = .03$). Finally, phonological fluency explained a further 7 % ($p = .03$) of the variance, once phonological fluency was entered into the model, receptive grammar and phonological awareness failed to reach statistical significance.

For writing accuracy, nonverbal ability again accounted for only 6 % of the variance whereas the language measures, in particular receptive grammar and

Table 7 Summary of hierarchical regression analysis for variables predicting the principal components: complexity, productivity and accuracy in the SLI group ($N = 46$)

Step	1. Complexity			2. Productivity			3. Accuracy		
	β	R^2	ΔR^2	β	R^2	ΔR^2	β	R^2	ΔR^2
1. Nonverbal ability	.31*	.18*		.01	.06		.02	.06	
2. Receptive vocabulary	−.07	.18	.00	−.23	.06	.00	−.14	.06	.00
3. Receptive grammar	.32*	.24	.06*	.26	.18	.12*	.32*	.18	.12*
4. Phonological awareness	.14	.24	.00	.20	.26	.08*	.06	.26	.08*
5. Phonological fluency	−.04	.24	.00	.41*	.33	.07*	−.04	.26	.00
6. Phonological STM	−.29	.24	.00	.06	.33	.00	.43*	.30	.04*
7. Word reading	−.07	.24	.00	.32	.34	.01	.56**	.40	.10**

Complexity: $F(7,45) = 2.67$, $p = .024$, $R^2 = .06$; Productivity: $F(7,45) = 4.28$, $p = .001$, $R^2 = .24$; Accuracy: $F(7,45) = 5.37$, $p < .001$, $R^2 = .40$

** $p < .01$, * $p < .05$ indicates a significant predictor variable

phonological awareness, were important contributors, increasing the variance explained to 26 %. Phonological STM and word reading also contributed to the variance explained for writing accuracy, ($R^2 = .40$) for the final model but not for writing complexity or productivity. After controlling for phonological STM, phonological awareness was no longer significantly associated with writing accuracy.

Discussion

The results of this study indicate that the oral language difficulties of children with SLI are related to their ability to produce written texts. The present study also highlighted the contribution of phonological STM and word reading to grammatical and spelling errors. These findings not only provide replication of the types of writing difficulties that children with SLI experience compared to chronological and language matched peers (Bishop & Clarkson, 2003; Fey et al., 2004; Mackie & Dockrell, 2004; Scott & Windsor, 2000; Windsor et al., 2000), but also show how their writing differed compared to children matched for reading decoding, emphasising the importance of both oral language and reading skills in writing performance.

Our first research question examined differences in fine grained writing measures in the SLI group compared to age, language, and reading matched children. As expected the SLI group performed worse in comparison to children matched for age on all measures of writing, but were comparable to the LA group on measures of productivity and sentence complexity, including the proportion of derivational morphemes produced, indicating that these measures of writing were delayed according to their level of language. The SLI group performed worse than the LA group, but comparable to the RA group in the proportion of orthographic spelling errors, providing support for the role of reading decoding in orthographic knowledge. Orthographic knowledge includes an understanding of writing conventions and acceptable letter sequences (Cassar & Treiman, 2004). Studies have demonstrated the importance of orthographic knowledge in predicting good spelling skills (Berninger, Abbott, Abbott, Graham, & Richards, 2002).

Consistent with prior research (e.g. Mackie & Dockrell, 2004; Windsor et al., 2000), children with SLI produced a greater number of omissions of the past tense—*ed* inflectional morpheme than all three comparison groups, reflecting the specific areas of difficulties evidenced in their oral language. The SLI group also produced a larger number of subject noun omissions, a characteristic which has been observed in the spoken language of children with SLI (Grela, 2003; Pizzioli and Schelstraete 2008). These omissions are more frequently observed in sentences of greater linguistic complexity. In the current study, given that so few complex sentences were attempted by the SLI group (and the LA/RA groups) we were unable to examine the interaction between frequency of omissions and sentence complexity. However, these findings are consistent with research which has shown that producing written sentences of greater complexity increases the frequency of subject-verb errors in young children (Negro et al., 2005), suggesting that subject noun omissions may result from an increase in processing load in constructing complex sentences.

Our second research question examined whether three constructs of writing (complexity, productivity, and accuracy) as demonstrated in typically developing children (Puranik et al., 2008; Wagner et al., 2010) were replicated in children with SLI. However, there were also differences between the SLI, LA, and RA groups. The most striking result was that writing fluency was strongly associated with components of writing productivity in the SLI group, compared to writing accuracy in the younger LA and RA groups. These results emphasise the importance of lower-order transcription skills such as spelling impacting on fluent writing in younger children. Beginning spellers have less knowledge of the precise representations of words and will provide a greater proportion of cognitive resources to spelling than older children. Evidence supporting this is provided in a number of studies which have shown that spelling predicts compositional fluency in younger children, but not in older children (Graham et al., 1997). In the SLI group writing fluency was associated with higher-order writing skills such as generating diverse vocabulary and story content, rather than transcription skills. The text generation process is directly linked with the components of oral language such as semantic knowledge and lexical retrieval (Berninger, 1999), suggesting that poor oral language skills in children with SLI is a contributing factor to low levels of productivity and subsequent difficulties in writing fluency.

Our final aim was to examine whether oral language, phonological STM, and word reading was able to explain variance in productivity, complexity, and accuracy in the SLI group. Of the oral language measures, it was receptive grammar that explained a significant proportion of the variance in writing complexity. The analysis revealed that children with SLI produced fewer words per clause and fewer coordinating sentences, relying on simple sentences containing only a main clause. The SLI were comparable with children matched for language and reading, suggesting that their immature written sentence construction is due to their delay in the acquisition of grammatical knowledge. Verbal fluency explained a significant proportion of the variance in writing productivity. Word retrieval is one of the primary skills involves in verbal fluency, i.e. problems in the ability to access and retrieve a word is believed to hinder verbal fluency (Menyuk, 1978). In children with SLI deficits in verbal fluency are not shown to be a result of problems in retrieval, but rather the strength and number of links between lexical items are insufficiently elaborated (McGregor, Newman, Reilly, Capone, 2002). According to Leonard (1998) this under elaborated network would make retrieval slower. Thus, given that children with SLI might have fewer and less elaborated language representations in memory and also demonstrate processing limitations a reliance on less diverse vocabulary in written tasks is likely to occur.

Phonological STM was only significantly associated with writing accuracy, not writing complexity or productivity, suggesting that difficulties in holding complex language information in memory may contribute to an increase in the production of spelling and omission errors in the written text of children with SLI. These findings would support research with typically developing children demonstrating an increase in written grammatical errors as task demands increase (Fayol et al., 1999). Phonological STM has been proposed as an explanatory mechanism for the elevated levels of grammatical errors in the speech of children with SLI. However, there is minimal evidence demonstrating significant etiological overlap between the domains (Bishop, Adams, & Norbury, 2005) suggesting that weak phonological STM does not account for the range of grammatical deficits seen in children with SLI. Deficits in phonological STM have also been proposed as a possible causal mechanism for literacy difficulties in children with SLI (Catts, Adlof, Hogan, & Ellis Weismer, 2005; Briscoe, Bishop, & Norbury, 2001). Conti-Ramsden and Durkin (2007) demonstrated a bidirectional relationship between phonological STM and reading in children with SLI between 11 and 14 years of age. Poor phonological STM ability predicted poor reading ability 4 years later, and early reading skill predicted later phonological STM, suggesting that reading acquisition can facilitate phonological STM performance. It can be suggested that both good phonological STM and competence in early reading skills can protect against poor written accuracy in children with SLI.

Limitations

Firstly, all children were attending mainstream schools, and our findings may not be applicable to children with SLI attending special schools. However, Dockrell, Lindsay, Palikara, & Cullen (2007) found no difference between children with SLI attending mainstream schools and special schools on a standardized measure of writing. Secondly, the type of written errors produced might be related to the narrative genre (Berman & Katzenberger, 2004). The proportion of omissions of past tense—*ed* might be less frequent if a written task were used that did not require a narrative structure. Further research is needed to specify the extent to which different linguistic skills are activated by different written tasks demands. Thirdly, writing was only assessed at one time point; future research which obtains information across time will be best placed to examine the stability of the principal component model across different development stages. Fourthly, components of executive control, such as attention, inhibition and writing processes such as self-regulation and evaluation were not assessed. Attention and executive function are highly associated with written expression and spelling in children (Hooper et al., 2011). Graham and Perin (2007) demonstrated in a meta-analysis of 20 studies, that providing instruction in self-regulation strategies contributed to the overall improvement of student's writing quality. Fifth, the CA group were not assessed on measures of language and reading; although, all children comprising the CA group were performing within the average range on classroom activities, as reported by the children's class teacher.

Conclusions

These findings provide evidence for the direct effects of oral language on writing constructs in children with SLI. Considering the disadvantages experienced by individuals who fail to achieve competency in writing proficiency, targeting these key areas of oral language may translate to improvements in the writing of children with SLI. Future research might consider the development of preventative interventions designed to target how oral language contributes to writing proficiency.

The findings also have implications for the role of phonological STM in the writing of children with SLI. One way to improve the writing of children with SLI would be to acknowledge their limitations in processing capacity and working memory in the development of writing skills, and to individualise interventions by reducing the number of components in the writing task to ease the processing load involved in producing a piece of written text. Previous research has shown that reading decoding skills support conventional spelling in children; one area of interest for future research is whether reading comprehension may support the development of writing skills in children with SLI, in particular areas such as lexical diversity and syntactic complexity (Bishop & Snowling, 2004). In addition, examining whether these study findings hold across different written genres raises an avenue for future research and how cognitive processes such as executive functioning can contribute to good writing in children with SLI.

Acknowledgments The Gatsby foundation supported the current investigation. Dr Mackie is supported by an MRC/ESRC Interdisciplinary Postdoctoral Research Fellowship (G0800060). The authors thank Becky Clarke who assisted with data collection, and the families, children and schools who participated.

Conflict of interest The authors declare no conflict of interest.

References

Abbott, R., & Berninger, V. (1993). Structural equation modeling of relationships among developmental skills and writing skills in primary and intermediate grade writers. *Journal of Educational Psychology, 85*(3), 478–508.

Beard, R. (2000). *Developing writing 3-13*. London: Hodder & Stoughton.
Bereiter, C., & Scardamalia, M. (1987). *The psychology of written composition*. Hillsdale, NJ: Lawrence Erlbaum Associates.
Berman, R. A., & Katzenberger, I. (2004). Form and function in introducing narrative and expository texts: A developmental perspective. *Discourse Processes, 38*, 57–94.
Berman, R. A., & Slobin, D. I. (1994). *Relating events in narrative: A crosslinguistic developmental study*. Hillsdale, NJ: Lawrence Erlbaum Associates.
Berninger, V. W. (1999). Coordinating transcription and text generation in working memory during composing: Automatic and constructive processes. *Learning Disability Quarterly, 22*, 99–112.
Berninger, V. W., Abbott, R. D., Abbott, S. P., Graham, S., & Richards, T. (2002). Writing and reading: Connections between language by hand and language by eye. *Journal of Learning Disabilities, 35*, 39–56.
Berninger, V. W., Abbott, R. D., Jones, J., Wolf, B. J., Gould, L., Anderson-Youngstrom, M., et al. (2006). Early development of language by hand: Composing, reading, listening and speaking connections: Three-letter writing modes; and fast mapping in spelling. *Developmental Neuropsychology, 29*, 61–92.
Berninger, V., & Fuller, F. (1992). Gender differences in orthographic, verbal, and compositional fluency: Implications for diagnosis of writing disabilities in primary grade children. *Journal of School Psychology, 30*, 363–382.
Berninger, V., & Whitaker, D. (1993). Theory-based, branching diagnosis of writing disabilities. *School Psychology Review, 22*, 623–642.
Bishop, D. V. M. (1989). *Test for reception of grammar* (2nd ed.). Age and Cognitive Performance Research Centre. Manchester: University of Manchester.
Bishop, D. V. M. (1997). *Uncommon understanding. Development and disorders of language comprehension in children*. Hove, East Sussex, UK: Psychology Press.
Bishop, D. V. M., Adams, C. V., & Norbury, C. F. (2005). Distinct genetic influences on grammar and phonological short-term memory deficits: Evidence from 6-year-old twins. *Genes, Brain and Behaviour, 5*, 158–169.
Bishop, D. V. M., & Clarkson, B. (2003). Written language as a window into residual language deficits: A study of children with persistent and residual speech and language impairments. *Cortex, 39*, 215–237.
Bishop, D. V. M., & Snowling, M. (2004). Developmental dyslexia and specific language impairment: Same or different? *Psychological Bulletin, 130*, 858–886.
Bourdin, B., & Fayol, M. (1994). Is written language production more difficult than oral language production? A working memory approach. *International Journal of Psychology, 29*, 591–620.
Briscoe, J., Bishop, D. V. M., & Norbury, C. F. (2001). Phonological processing, language, and literacy: A comparison of children with mild-to-moderate sensorineural hearing loss and those with specific language impairment. *Journal of Child Psychology and Psychiatry, 42*, 329–340.
Brown, T. A. (2006). *Confirmatory factor analysis for applied research*. NY: New York Guilford.
Bruck, M., Treiman, R., Caravolas, M., Genesee, F., & Cassar, M. (1998). Spelling skills of children in whole language and phonics classrooms. *Applied Psycholinguistics, 19*, 669–684.
Caravolas, M., Hulme, C., & Snowling, M. J. (2001). The foundations of spelling ability: Evidence from a three year longitudinal study. *Journal of Memory and Language, 45*, 751–774.
Cassar, M., & Treiman, R. (2004). Developmental variations in spelling: Comparing typical and poor spellers. In C. Stone, E. Silliman, B. J. Ehren, & K. Apel (Eds.), *Handbook of language and literacy: Development and disorders* (pp. 627–643). New York, NY: The Guilford Press.
Catts, H. W., Adlof, S. M., Hogan, T. P., & Ellis Weismer, S. E. (2005). Are specific language impairment and dyslexia distinct disorders? *Journal of Speech, Language, and Hearing Research, 48*, 1378–1396.
Conti-Ramsden, G. (2003). Processing and linguistic markers in young children with specific language impairment. *Journal of Speech, Language and Hearing Research, 46*, 1029–1037.
Conti-Ramsden, G. M., & Durkin, K. (2007). Phonological short-term memory, language and literacy: Developmental relationships in early adolescence in young people with SLI. *Journal of Child Psychology and Psychiatry, 48*, 147–156.
Cragg, L., & Nation, K. (2006). Exploring written narrative in children with poor reading comprehension. *Educational Psychology, 26*, 55–72.
Dockrell, J., & Lindsay, G. (1998). The ways in which speech and language difficulties impact on children's access to the curriculum. *Child Language Teaching and Therapy, 14*, 117–133.

Dockrell, J., Lindsay, G., & Connelly, V. (2009). The impact of specific language impairment on adolescents' written text. *Exceptional Children, 75*, 427–446.

Dockrell, J., Lindsay, G., Connelly, V., & Mackie, C. (2007). Constraints in the production of written texts of children with specific language impairments. *Exceptional Children, 73*, 147–164.

Dockrell, J., Lindsay, G., Palikara, O., & Cullen, M. A. (2007). *Raising the achievements of children and young people with specific speech and language difficulties and other special educational needs through school, to work and college. RR837.* Nottingham, UK: DfES.

Dunn, L., Dunn, L., Whetton, C., & Burley, J. (1997). *British picture vocabulary scale*. Windsor, UK: NFER-Nelson.

Elliott, C. D., Smith, P., & McCulloch, K. (1997). *British ability scales II*. Windsor, UK: NFER-Nelson.

Fayol, M., Hupet, M., & Largy, P. (1999). The acquisition of subject-verb agreement in written French: From novices to experts' error. *Reading and Writing; An Interdisciplinary Journal, 11*, 153–174.

Fey, M. E., Catts, H. W., Proctor-Williams, K., Tomblin, J. B., & Zhang, X. (2004). Oral and written story composition skills of children with language impairment. *Journal of Speech Language and Hearing Research, 47*, 1301–1318.

Fitzgerald, J., & Shanahan, T. (2000). Reading and writing relations and their development. *Educational Psychologist, 35*, 39–50.

Frederickson, N., Frith, U., & Reason, R. (1997). *The phonological assessment battery*. Windsor, UK: NFER–Nelson.

Gathercole, S. E. (2006). Nonword repetition and word learning: The nature of the relationship. *Applied Psycholinguistics, 27*, 513–543.

Gathercole, S. E., & Baddeley, A. D. (1990). Phonological memory deficits in language disordered children: Is there a causal connection? *Journal of Memory and Language, 29*, 336–360.

Gathercole, S. E., & Baddeley, A. D. (1996). *The children's test of nonword repetition*. London, UK: The Psychological Corporation.

Gillam, R. B., & Johnston, J. R. (1992). Spoken and written language relationships in language/learning-impaired and normally achieving school age children. *Journal of Speech and Hearing Research, 35*, 1303–1315.

Graham, S. (2006). Writing. In P. A. Alexander & P. Winne (Eds.), *Handbook of educational psychology*. Mahwah, NJ: Lawrence Erlbaum Associates.

Graham, S., Berninger, V. W., Abbott, R. D., Abbott, S. P., & Whitaker, D. (1997). Role of mechanics in comparing elementary school students: A new methodological approach. *Journal of Educational Psychology, 89*, 170–182.

Graham, S., Harris, K. R., & Loynachan, C. (1993). The basic spelling vocabulary list. *Journal of Educational Research, 86*, 363–368.

Graham, S., & Perin, D. (2007). A meta-analysis of writing instruction for adolescent students. *Journal of Educational Psychology, 99*, 445–476.

Grela, B. G. (2003). The omission of subject arguments in children with specific language impairment. *Clinical Linguistics and Phonetics, 17*, 153–169.

Hayes, J. R., & Flower, L. (1986). Writing research and the writer. *American Psychologist, 41*, 1106–1113.

Hooper, S. R., Costa, L.-J., McBee, M., Anderson, K. L., Yerby, D. C., Knuth, S. B., et al. (2011). Concurrent and longitudinal neuropsychological contributors to written language expression in first and second grade students. *Reading and Writing: An Interdisciplinary Journal, 24*, 221–252.

Kellogg, R. T. (2001). Competition for working memory among writing processes. *American Journal of Psychology, 114*, 175–192.

Leonard, L. B. (1998). *Children with specific language impairment*. Cambridge, MA: The MIT Press.

Leonard, L. B., Eyer, J., Bedore, L., & Grela, B. (1997). Three accounts of the grammatical morpheme difficulties of English-speaking children with specific language impairment. *Journal of Speech, Language and Hearing Research, 40*, 741–753.

Leonard, L. B., Deevy, P., Miller, C. A., Charest, M., Kurtz, R., & Rauf, L. (2003). The use of grammatical morphemes reflecting aspect and modality by children with specific language impairment. *Journal of Child Language, 30*, 769–795.

Mackie, C., & Dockrell, J. (2004). The nature of written language deficits in children with SLI. *Journal of Speech, Language, and Hearing Research, 47*, 1469–1483.

McCutchen, D. (2000). Knowledge, processing, and working memory: Implications for a theory of writing. *Educational Psychologist, 35*, 13–23.

McGregor, K. K., Newman, R. M., Reilly, R., & Capone, N. C. (2002). Semantic representation and naming in children with specific language impairment. *Journal of Speech, Language, and Hearing Research, 45*, 998–1014.

Menyuk, P. (1978). Linguistic problems in children with developmental dysphasia. In M. Wyke (Ed.), *Developmental dysphasia* (pp. 135–158). London, UK: Academic Press.

Miller, J. F., & Chapman, R. (2000). *SALT: Systematic analysis of language transcripts*. Research version 6.1. Madison, WI: Language Analysis Lab, University of Wisconsin.

Miller, C. A., Kail, R. V., Leonard, L. B., & Tomblin, J. B. (2001). Speed of processing in children with specific language impairment. *Journal of Speech, Language, and Hearing Research, 44*, 416–433.

Montgomery, J., & Windsor, J. (2007). Examining the language performances of children with and without specific language impairment: Contributions of phonological short-term memory. *Journal of Speech, Language and Hearing Research, 50*, 778–796.

Muter, V., Hulme, C., Snowling, M. J., & Stevenson, J. (2004). Phonemes, rimes, vocabulary, grammatical skill as foundations for early reading development: Evidence from a longitudinal study. *Developmental Psychology, 40*, 665–681.

Negro, I., Chanquoy, L., Fayol, M., & Louis-Sidney, M. (2005). Subject verb agreement in children and adults: Serial and hierarchical processing? *Journal of Psycholinguistic Research, 34*, 233–258.

Perera, K. (1984). *Children's writing and reading: Analyzing classroom language*. Oxford: Basil Blackwell.

Pizzioli, F., & Schelstraete, M. A. (2008). The argument-structure complexity effect in children with specific language impairment: Evidence from the use of grammatical morphemes in French. *Journal of Speech, Language, and Hearing Research, 51*, 706–721.

Puranik, C. S., Lombardino, L. J., & Altmann, L. J. (2007). Writing through retellings: An exploratory study of language-impaired and dyslexic populations. *Reading and Writing, 3*, 251–272.

Puranik, C. S., Lombardino, L. J., & Altmann, L. J. P. (2008). Assessing the microstructure of written language using a retelling paradigm. *American Journal of Speech Language Pathology, 17*, 107–120.

Reilly, J., Losh, M., Bellugi, U., & Wulfeck, B. (2004). "Frog, where are you?" Narratives in children with specific language impairment, early focal brain injury, and Williams syndrome. *Brain and Language, 88*, 229–247.

Rice, M., & Oetting, J. (1993). Morphological deficits of children with SLI: Evaluation of number marking and agreement relations. *Journal of Speech and Hearing Research, 36*, 1249–1257.

Rice, M. L., & Wexler, K. (1996). Towards tense as a clinical marker of specific language impairment in English-speaking children. *Journal of Speech and Hearing Research, 39*, 1239–1257.

Scott, C., & Windsor, J. (2000). General language performance measures in spoken and written discourse produced by school-age children with and without language learning disabilities. *Journal of Speech, Language, and Hearing Research, 43*, 324–339.

StataCorp. (2003). *Stata statistical software release 8*. College Station, TX: StataCorp LP.

Stein, N. L., & Glenn, C. G. (1982). Children's concept of time: The development of story schema. In W. J. Friedman (Ed.), *The developmental psychology of time* (pp. 225–281). San Diego, CA: Academic Press.

Torrance, M., & Galbraith, D. (2006). The processing demands of writing. In C. A. MacArthur, S. Graham, & J. Fitzgerald (Eds.), *Handbook of writing research* (pp. 67–82). New York, NY: The Guilford Press.

van der Lely, H. K. J., & Christian, V. (2000). Lexical word formation in Grammatical SLI children: A grammar-specific or input-processing deficit? *Cognition, 75*, 33–63.

Wagner, R. K., Puranik, C. S., Foorman, B., Foster, E., Wilson, L. G., Tschinkel, E., et al. (2010). Modelling the development of written language. *Reading and Writing: An Interdisciplinary Journal, 24*, 203–220.

Windsor, J., Scott, C. M., & Street, C. K. (2000). Verb and noun morphology the spoken and written language of children with language learning disabilities. *Journal of Speech, Language and Hearing Research, 43*, 1322–1336.

Zourou, F., Ecalle, J., Maynan, A., & Sanchez, M. (2010). The fragile nature of phonological awareness in children with specific language impairment: Evidence from literacy development. *Child Language Teaching and Therapy, 26*, 347–358.