WORKING MEMORY AND NARRATIVES IN CHILDREN WITH SPECIFIC LANGUAGE IMPAIRMENT AND RESOLVED LATE TALKERS

Submitted by

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List of Abbreviations

ANOVA	Analysis of variance
CANTAB	Cambridge Neuropsychological Test Automated Battery
CDI	MacArthur-Bates Communicative Development Inventories
CELF-3	Clinical Evaluation of Language Fundamentals – Third Edition
CELF-4	Clinical Evaluation of Language Fundamentals – Fourth Edition
CELF-P	Clinical Evaluation of Language Fundamentals – Preschool
CELF-P2	Clinical Evaluation of Language Fundamentals–Preschool, Second Edition
CELF-R	Clinical Evaluation of Language Fundamentals – Revised
CLPT	Competing Language Processing Task
CMS	Children's Memory Scale
CNRep	Children's Test of Nonword Repetition
ELD	Expressive language disorder
ELVS	Early Language in Victoria Study
EOI	Extended Optional Infinitive
ERRNI	Expression, Reception and Recall of Narrative Instrument
HELD	History of expressive language delay
HSD	Honestly Significant Difference
K-ABC	Kaufman Assessment Battery for Children
K-Bit	Kaufman Brief Intelligence Test
LDS	Language Development Survey
LGA	Local government area
MANOVA	Multivariate analysis of variance
NRT	Nonword Repetition Test

RLT	Resolved late talker
SCR	Subordinate Clause Ratio
SEIFA	Socio-Economic Indexes for Areas
SES	Socio Economic Status
SLI	Specific Language Impairment
TENR	Test of Early Nonword Repetition
TLD	Typical language development
TNL	Test of Narrative Language
TOLD:P-3	Test of Language Development – Primary: 3
WMTB-C	Working Memory Test Battery for Children
WPPSI-R	Wechsler Intelligence test for Preschool – Revised

Summary

Late talking is a risk factor for Specific Language Impairment (SLI). Although a large proportion of late talkers show language in the normal range by age 4 years (and are judged to be “resolved”), working memory and higher order language skills may be affected. Within a longitudinal study using a large representative, community-based sample of infants recruited at mean age 8 months, the present research was designed to identify the working memory profiles of 5-year-old children with SLI, resolved late talkers (RLT) and children with typical language development (TLD), and to compare their narrative skills. The participants, aged 5;0-5;6 years, were 25 children with SLI and 45 RLTs, all identified as late talkers at age 2 years, and a group of 32 children with TLD. The SLI group showed significantly poorer performance than the other two groups on measures of the phonological loop and episodic buffer, and had impaired visuospatial working memory in tasks tapping into the central executive component of working memory. Despite early language delay, the RLTs did not show deficits in working memory relative to children with TLD at age 5 years. In fact, the findings of this study suggest an advantage in the storage and processing of visuospatial material in RLTs. As reported in previous research, working memory was associated with the generation and comprehension of narratives. On the generation and recall of narratives from a picture sequence, the SLI group performed similarly to the TLD group, but included less information than the RLT group and had lower inferencing scores relative to the other two groups. In addition, in comparison to the SLI group, the RLTs were more likely to have higher global plot structure scores, include more clauses in their narratives, use more subordinate clauses and show greater diversity in the verbs used. Variability in all three groups was found, particularly in the narratives, indicating that there is great variability in working memory and narrative development, which takes place over a number of years.

Future research using longitudinal data would contribute more to our understanding of the developmental trajectories of working memory and narrative skills for late talkers who resolve and those who go on to be language impaired.

Statement of Authorship

Except where reference is made in the text of the thesis, this thesis contains no material published elsewhere or extracted in whole or in part from a thesis submitted for the award of any other degree or diploma.

No other person's work has been used without due acknowledgment in the main text of the thesis.

The thesis has not been submitted for the award of any degree or diploma in any other tertiary institution.

All research procedures reported in this thesis were approved by the La Trobe University Human Ethics Committee (Approval number 07-150) and The Royal Children's Hospital Human Research Ethics Committee (Approval number 27078 D).

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CHAPTER 1

INTRODUCTION

Children's language develops over a period of time but between 12 and 24 months of age their production increases dramatically. However, for some otherwise healthy children, early language development is delayed; they understand less and begin to talk much later than other children. Delayed language development can be reliably identified at 24 months, at which time these children are commonly referred to as "late talkers" (Rice, Taylor, & Zubrick, 2008; Roos & Ellis Weismer, 2008). Approximately 50% to 70% of late talkers "recover" from the late start and go on to demonstrate language abilities within the normal range during preschool or early school years (Dale, Price, Bishop, & Plomin, 2003; Paul, Hernandez, Taylor, & Johnson, 1996; Paul, Spangle-Looney, & Dahm, 1991), while other children demonstrate persisting language impairments. For children who do not demonstrate other developmental problems, late talking status can be the first diagnostic symptom of Specific Language Impairment (SLI; Zubrick, Taylor, Rice, & Slegers, 2007). Although many late talkers perform within normal limits on formal language measures by early school age, research has shown that late talkers experience weaknesses in language when compared to typically developing children (Paul, et al., 1996; Rescorla, 2002; Roos & Ellis Weismer, 2008). Though not significant enough to be classified as a delay, this weakness in language could significantly impact upon academic success.

SLI is a developmental disorder that affects receptive and/or expressive language in the context of preserved nonverbal intelligence, no neurological impairments, and adequate hearing. SLI is reliably identified after 4 years of age, at which time the trajectory of language development in children becomes stable (Leonard, 1998; Tomblin, 2009).

Despite the requirement of normal nonverbal cognitive ability for the diagnosis of SLI, there is much evidence to suggest that the difficulties of children with SLI may not be completely “language specific” (Hick, Botting, & Conti-Ramsden, 2005a). As such, there has been a proliferation of research investigating the working memory of children with SLI (Archibald & Gathercole, 2006b; Archibald & Joanisse, 2009; Dodwell & Bavin, 2008; Ellis Weismer, Evans, & Hesketh, 1999). The working memory model originally proposed by Baddeley and Hitch (1974) and later updated by Baddeley (2000) has guided much of this research. The cognitive impairments in children with SLI have typically been characterised as a deficit in phonological working memory (Briscoe & Rankin, 2009; Ellis Weismer, et al., 1999; Gathercole & Baddeley, 1990; Hick, et al., 2005a; Nickisch & von Kries, 2009; Norbury & Bishop, 2002), even when the tasks testing memory do not involve language to any great extent (Im-Bolter, Johnson, & Pascual-Leone, 2006). Other research (Conti-Ramsden, Botting, & Faragher, 2001; Laws & Bishop, 2003) has shown other memory and cognitive limitations, which will be discussed in later chapters of this thesis. There are, however, gaps in our knowledge of the relationship between memory and language impairment, and there is a paucity of research investigating working memory of resolved late talkers (RLTs), that is, children with a history of late talking, despite normal language abilities at preschool or school-entry age.

Higher order language skills involved in narratives, like the skills involved in everyday spontaneous speech and comprehension of verbal input, require the integration of linguistic and nonverbal cognitive abilities. To examine the links between cognitive skills and language, an oral narrative task was included in the current research. To engage in narrative tasks, children need to construct a mental model of the events and maintain this representation in memory, which places demands on linguistic and cognitive abilities, attentional resources and memory (Boudreau, 2007).

The narratives of children with SLI have attracted ongoing research as children with language difficulties are often disadvantaged in the classroom setting, where proficiency in this area contributes to the acquisition of literacy and overall academic success (Epstein & Phillips, 2009; Paul, et al., 1996). Children with SLI have been shown to experience difficulties in constructing and retelling narratives, including fewer main ideas, as well as difficulties in the comprehension of narratives (Bishop & Adams, 1992; Crais & Chapman, 1987; Ellis Weismer, 1985). Additionally, some studies show that children with SLI experience difficulty in the use of linguistic structures to produce a connected narrative, including lexical diversity and complex syntax (Gummersall & Strong, 1999; Norbury & Bishop, 2003). Limited research has investigated whether RLTs demonstrate impaired narrative skills during their preschool to early school years and the results of the research that has been conducted are inconsistent (Manhardt & Rescorla, 2002; Paul, et al., 1996).

Therefore, the aim of this research was to identify the working memory profiles and narrative skills of 5-year-old children with SLI, RLTs and their typically developing peers. The children were all participating in a longitudinal population-based study, the Early Language in Victoria Study (ELVS), in which 1,910 children are being studied from infancy (8 months of age) to school age (7 years) in order to document the pathways of language and early literacy development. In the current study, each component of Baddeley's (2001) model of working memory, which is the predominant model in the field, was assessed and a narrative task was included to explore the relationship between memory storage and processing and language skills. Chapter 2 of this thesis outlines some of the current accounts of SLI and reviews research on SLI and late talkers. Chapter 3 examines the prominent models of working memory, with particular focus on Baddeley's (2001) model, and discusses the role of working memory in language acquisition. This is followed by a discussion of studies that have examined working memory in children with SLI and RLTs. A review of the literature examining the typical development of narrative skills, as well as the narrative skills of children with SLI and RLTs is presented in Chapter 4.

Three studies were conducted in the current research. The first study (Chapter 5) examined the components of Baddeley's model of working memory in three groups of children: children with SLI, RLTs, and children with typical language development (TLD). Study Two (Chapter 6) examined the performance of children with SLI and RLTs in comparison to typically developing children on tasks of narrative generation, recall, and comprehension. Given the established links between memory and language development, Study Two explored the extent to which working memory abilities are involved in the higher order language skills of telling a story, recalling it, and comprehending it. Chapter 7 presents the third study in which the narratives the child told were coded for global plot structure, narrative length and syntactic complexity, evaluative devices, and referential devices in an effort to identify group similarities and differences. Chapter 8 presents an overall discussion of the research. It focuses on the theoretical and clinical implications of the findings.

CHAPTER 2

AN INTRODUCTION TO SPECIFIC LANGUAGE IMPAIRMENT AND RESOLVED LATE TALKERS

Introduction to Specific Language Impairment

SLI is identified when a child has language skills below chronological age expectations and this cannot be explained by below normal nonverbal intelligence, sensory impairments, environmental deficiencies, or a social-pragmatic profile associated with autistic spectrum disorders (Archibald & Gathercole, 2007a; Laws & Bishop, 2004). Language difficulties may be characterized by weak grammatical and lexical knowledge, as well as problems with word retrieval, sentence construction, or comprehension (Briscoe & Rankin, 2009; Leonard, 1998). An extensively documented problem in children with SLI is a deficit in the use of grammatical morphology, particularly verb inflections. Children with this deficit make less use of third person singular *–s* and past tense *–ed* inflections, and the copula and auxiliary forms of *be* (Leonard, 2009). Children are typically assessed using standardised language tests where the critical cut-off score varies between 1 and 2 standard deviations below the mean in most research studies. Using a criterion of 1.25 standard deviations below the mean, which is currently the most frequently adopted criterion, the prevalence of SLI in the general population is about 7% (Tomblin, Records, & Zhang, 1996).

The prevalence of SLI is of particular concern given the associated risk for later social, behavioural, and academic difficulties. Tomblin, Zhang, Buckwalter, and Catts (2000) found that at age 8 years, 52% of 164 children with SLI had some form of reading disorder, and clinical levels of behaviour disorders were found in 26% of the children. Similarly, Botting and Conti-Ramsden (2000) documented children with SLI experiencing behavioural difficulties of an emotional, social, and anti-social nature as a secondary result of their primary language difficulties. Further research by Conti-Ramsden, Botting, Simkin, and Knox (2001) showed that 89% of children identified with SLI at 7 years continued to show some degree of language impairment at age 11 years.

The language of children with SLI is typically delayed in onset. Although these children are slower to acquire language, the developmental trajectory of their language follows the same course as found in typically developing children (Leonard, 1998). For example, Rice, Redmond, and Hoffman (2006) propose that children with SLI demonstrate delayed development of vocabulary, mean length of utterance, and grammatical tense marking; that is, the children are older at the initial stages of development. However, once the growth trajectories are underway, the linguistic systems show a highly similar developmental pattern as in typically developing children. The long-term nature of SLI is unclear. Children with SLI may change their status over the course of their development with some appearing to resolve (Bishop & Adams, 1990). However, residual evidence can persist in higher-order language skills (Montgomery, 2000). Conversely, children with SLI may continue to have significant language problems throughout their development (Leonard, 1998). Research findings have demonstrated that once children with SLI approach school age, they are likely to have poor language abilities throughout childhood and into adulthood (Bishop & Edmundson, 1987). Tomblin, Zhang, Buckwalter, and O'Brien (2000) suggest that the apparent "recovery" of language abilities in SLI is due to the effect of regression to the mean that is inherent when measures that contain measurement error are used to classify children. Some of the children initially classified as SLI may later be classified differently; thus when assessed again, their language impairment will appear to have resolved when, in fact, their true ability has not changed.

Clinicians and researchers alike have long recognized the marked heterogeneity in the language profiles of children with SLI (Archibald & Joanisse, 2009; Montgomery, 2002). Three broad subgroups of SLI have been identified: expressive SLI, receptive SLI, and mixed expressive-receptive SLI (Nickisch & von Kries, 2009). For example, in expressive SLI, only the expressive language abilities are below average, whereas the receptive skills (e.g., comprehension) are within the normal range. It is unclear whether there is a common genetic origin to the different clinical presentations or whether SLI serves as an umbrella term for an etiologically diverse mixture of subtypes (Bishop, 2002). Due to the heterogeneity in SLI, there is unlikely to be one causal mechanism (Laws & Bishop, 2003). Rather risk factors, such as family history, have been identified (Bishop, North, & Donlan, 1996). Several researchers have suggested clinical markers of SLI, including nonword repetition (Bishop, et al., 1996), sentence recall (Conti-Ramsden, Botting, & Faragher, 2001), and finite verb morphology (Rice & Wexler, 1996).

Given the relatively high prevalence of SLI and the potential long-term problems in the areas of social, academic, and behavioural functioning, much research has been conducted to attempt to explain the language deficits in children with SLI. Current approaches can be grouped broadly into either competence or performance based models. Competence models propose the impairments are reflective of problems in the children's underlying grammar (Rice & Wexler, 1996). For example, the late acquisition of grammatical morphemes is characteristic of expressive SLI. Rice (2000) argues that the clinical observation of the use of grammatical morphemes provides a sensitive assessment of SLI. Performance models, in contrast, propose that the language difficulties are secondary to cognitive or information processing deficits (Ellis Weismer & Evans, 2002). For example, Montgomery (2000; 2002; 2003) argues that children with SLI have slower online language processing abilities than typically developing children. The children with SLI have fewer cognitive resources to allocate and coordinate across various aspects of a task, and poor performance occurs when task demands exceed the available cognitive resources.

The Extended Optional Infinitive (EOI) account is one example of a competence model of SLI. Rice and Wexler (Rice & Wexler, 1996; Rice, Wexler, & Hershberger, 1998) proposed that young typically developing children, as well as children with SLI, go through a stage in which they treat tense and agreement morphemes as optional in main clauses. However, it is proposed that for children with SLI this stage is significantly extended. In this account, past tense *-ed*, third person singular *-s*, *BE* and *DO* are regarded as finiteness markers. During this "optional infinitive" stage, while children know the grammatical properties of finiteness they lack the knowledge that tense is required in main clauses and may, at times, use an infinitive when a finite form is necessary; for example, *Daddy like ice-cream*, for *Daddy likes ice-cream*. Of note, if finiteness markers are present, they are used correctly (Rice, Wexler, & Cleave, 1995). The EOI account of SLI has been validated in a number of studies (e.g., Leonard, Eyer, Bedore, & Grela, 1997; Rice, et al., 1995). For example, Rice and colleagues (1995) found that 75% of 5-year-old children with SLI omitted tense markings, *–s* and *–ed*, to lexical verbs compared to approximately 50% of 3-year-old children with TLD.

Competence models of SLI, such as the EOI account, have generated much research into deficits in selected areas of language functioning. However, at the same time they typically ignore the nonlinguistic deficits experienced by children with SLI. The performance models of SLI propose that the problem may not rest with language per se, but rather with the children's ability to process and store information sufficiently for language development. Processing can refer to the speed required to perform a task or to the capacity (or work space) available to perform the necessary cognitive operations (Leonard, 2009). Processing capacity is typically assessed through verbal working memory tasks and this will be the focus of this thesis; it will be discussed in detail in Chapter 3. A brief review of Kail's (1994) Generalised Slowing Hypothesis will now follow.

Kail (1994) proposed that children with SLI are slower to process information compared to typically developing children across all cognitive domains, not just language. Kail demonstrated that children with SLI were approximately 33% slower than children with TLD on a wide range of tasks, including picture naming or judging whether two abstract designs are identical. Since this study, other researchers have found further support for this hypothesis, though with slightly smaller percentages of slowing relative to typically developing children. For example, Miller, Kail, Leonard, and Tomblin (2001) found a generalized proportion of slowing of about 20% across a range of linguistic and nonlinguistic tasks. However, not all studies have found that children with SLI perform tasks more slowly than their age- and language-matched typically developing peers (e.g., Crosby, Howard, & Dodd, 2004).

Introduction to Late Talkers

Given that the identification of SLI depends upon delays in expected patterns of language development, children at risk for SLI are rarely identified before 18 to 24 months-of-age, at which time these children are referred to as late talkers (Bishop & Edmundson, 1987; Desmarais, Sylvestre, Meyer, Bairati, & Rouleau, 2008; Rescorla, 2009). These are children who at 2 years of age show a delay in language production (Rescorla & Roberts, 2002). Between 20% and 70% of late talkers have been reported to be subsequently identified as SLI by school age (Leonard, 1998; Paul, 1993). Although a large proportion of late talkers may “catch-up”, there are reports that some of these RLTs have residual problems.

Like children with SLI, late talkers do not constitute a homogeneous group; some late talkers have an expressive delay only, whereas others may also have delayed receptive language. Children are typically identified as late talkers at age 2 years in one of two ways: (1) they use fewer than 50 words or are not combining words, measured by the Language Development Survey (LDS; Rescorla, 1989), or (2) they score at or below the 10^{th} percentile for vocabulary production on the MacArthur-Bates Communicative Development Inventories (CDI; Fenson et al., 1993). Both of these measures require a parent to select the words his or her child produces from a fixed number of vocabulary words (Roos & Ellis Weismer, 2008). Recent normative information for the CDI reveals that girls aged 24 months performing at the 10^{th} percentile have an expressive vocabulary of 92 words, while boys of the same age have an expressive vocabulary of 63 words (Fenson et al., 2007). The CDI, a parent report measure of early lexical and grammatical skills, has been used extensively to study language development in typically developing toddlers and young children with delayed expressive language development in the context of otherwise typical development (Ellis Weismer, 2007; Horwitz et al., 2003; Stokes & Klee, 2009).

Research in the USA has documented that approximately 15% of 2-year-old children have expressive language delays as measured by the CDI (Horwitz, et al., 2003). Recently two longitudinal studies have investigated language emergence in population-based samples of Australian children. Zubrick, Taylor, Rice, and Slegers (2007) determined the prevalence of late talkers in an Australian population-based sample of 1,766 children at age 24 months. Children were classified as late talkers if they scored more than 1 standard deviation below the mean on the six-item Communication Scale of the Ages and Stages Questionnaire

(Bricker & Squires, 1999). Using the maternal report instrument that assesses early comprehension and production, 13.4% of children were classified as having delayed language acquisition. The ELVS reported a slightly higher percentage (Reilly et al., 2007); 19.7% of children (333 of 1691 children) aged 24 months were classified as late talkers using the CDI (Fenson, et al., 1993) with a 10^{th} percentile cut-off.

Rescorla (2002, 2005) proposed that both late talkers and children with SLI have weak language systems but some late talkers are less severely impaired and “resolve”; that is, they perform in the normal range on standardized language assessments when assessed at a later time (D'Odorico, Assanelli, Franco, & Jacob, 2007). RLTs therefore demonstrate a better outcome than children who go on to be identified as SLI. However, research illustrates that RLTs’ language often lags behind that of typically developing children through childhood and early adolescence, making them vulnerable to learning difficulties (Bishop & Edmundson, 1987; Rescorla, 2002, 2005).

Several studies have reported outcome data for late talkers. For example, Girolametto, Wiigs, Smyth, Weitzman, and Pearce (2001) followed 21 children identified as late talkers at 24- to 33-months using the CDI (Fenson, et al., 1993) until age 5 years. Despite most of the late talkers performing in the normal range on various language assessments at age 5, they performed significantly poorer than children with TLD on most of the measures. Group differences were particularly evident on complex language skills, such as narrating a story. Ellis Weismer (2007) also discussed the long-term outcomes of 40 children identified as late talkers at 2 years using the CDI (Fenson, et al., 1993), noting that very few children were identified with SLI at 5 ½ years of age. Only 7.5% (3 out of 40) of late talkers scored at least 1 standard deviation below the mean on the measure of expressive language; the speaking quotient of the Test of Language Development-Primary: 3 (TOLD:P-

3; Newcomer & Hammill, 1997), and no child scored beyond the normal range for the listening quotient. However, 37.5% (15 out of 40) were receiving speech-language intervention. These results suggest that although most late talkers exhibit normal language skills by 5 years, they continue to show difficulties in some dimensions of language (Ellis Weismer, 2007).

Limited findings exist regarding the language outcomes of late talkers beyond the age of 5 years. Rice, Taylor, and Zubrick (2008) reported the language outcomes of 128 7-year-old children identified as late talkers at 24 months and 109 7-year-old children with TLD. At age 24 months, the late talkers had a vocabulary of fewer than 70 words on the LDS (Rescorla, 1989) or no word combinations on the Ages and Stages Questionnaire (Bricker & Squires, 1999). The children were recruited from the Australian population-based longitudinal study of children's health and development from birth to 8 years, as reported in Zubrick et al. (2007). At age 7 years, the groups did not differ on the measure of nonverbal intelligence, and group means were within the normal range on a global measure of language. However, Rice and colleagues found that the late talkers performed significantly poorer than their typically developing peers on measures of general language ability, vocabulary, speech development, semantics, syntax, and grammatical tense marking. Furthermore, using the criterion of 1 standard deviation below the mean, relative to typically developing children, a significantly greater percentage of late talkers were impaired on measures of general language ability (20% versus 11%), speech (7% versus 2%), syntax (18% versus 8%) and morphosyntax (9-23% versus 2-14%). This research demonstrates that, at age 7 years, late talkers are at heightened risk for persistent difficulties on a range of speech and language measures. Furthermore, the impaired morphosyntactic development observed in the late talkers is consistent with impaired performance on third-person singular *–s* and past tense marking commonly found in children with SLI (Rice, et al., 1998).

Rescorla (2002, 2005, 2009) conducted a longitudinal study investigating the language and reading abilities of a group of children from the age of 6 to 17 years who at 24 to 31 months were identified as late talkers. They all scored at least six months below their chronological age on the Reynell Expressive Language Scale (Reynell & Gruber, 1990). Rescorla's original cohort of children included 34 late talkers and 25 typically developing children matched on age, socio-economic status and nonverbal cognitive ability. By age 6 years, on the basis of continuing significant delays in expressive language skills approximately 17% of the late talkers were identified with SLI. A variety of standardised and nonstandardised nonverbal cognitive, language, and academic achievement measures were administered over the following years. At ages 6, 7, and 8 years, late talkers had lower vocabulary scores than their peers, and at 6 and 8 years lower scores on grammar. At 6 years, the groups also differed on pre-literacy measures and on a sentence repetition task. Of note, the children did not differ on reading measures at 6 and 7 years and this may have been due to variability in emerging reading skills in both groups, since at ages 8 and 9, when reading skills are established, the children differed significantly on reading measures.

At age 17 years, despite performance generally in the average range or above on language and reading/writing measures and comparable nonverbal cognitive abilities, the late talkers continued to perform significantly lower than their peers on measures tapping their word definition, lexical, and grammatical skills (Vocabulary/ Grammar factor) and their ability to recall lists of digits, narratives, and word pairs (Verbal Memory factor; Rescorla, 2009). Furthermore, parent-reported vocabulary scores on the LDS (Rescorla, 1989) at 2 years significantly predicted vocabulary, grammatical, and verbal memory scores at age 17 years, suggesting stability in language functioning over 15 years. Rescorla suggested that weaknesses in language might arise from weaknesses in one or more of the skills that subserve language, such as verbal working memory and auditory perception (Rescorla, 2009). Overall, this body of literature successfully demonstrates that children, who had acquired few words or were not combining words by 24 months but were no longer language impaired at follow-up, continued to experience a weakness in language-related skills into late adolescence relative to typically developing children.

CHAPTER 3

WORKING MEMORY: CHILDREN WITH SPECIFIC LANGUAGE IMPAIRMENT AND RESOLVED LATE TALKERS

Models of Working Memory

Recent research has focused on investigating the cognitive processes that underlie the language impairments of children with SLI, with many of the studies implicating deficits in working memory as playing a primary role in the developmental language disorder (Archibald & Gathercole, 2006b; Gathercole & Baddeley, 1990; Montgomery, 2000; Montgomery, Magimairaj, & Finney, 2010). Language production and comprehension relies on the ability to actively store and process linguistic information within working memory. Such processing requires numerous cognitive resources, and it is argued that children with SLI have a limited pool of resources due to capacity limitations, resulting in impaired language production or comprehension (Just & Carpenter, 1992; Montgomery, 2002). Two prominent models of working memory are Baddeley's model of working memory (Baddeley, 2000; Baddeley & Hitch, 1974) and the Capacity Theory of Comprehension (Daneman & Carpenter, 1983; Just & Carpenter, 1992). A brief description of both of these models will follow, with some consideration to the developmental nature of memory. The model of working memory developed originally by Baddeley and Hitch (1974) and extended by Baddeley (2000) has guided much of the research investigating the relation between working memory and language abilities in children with SLI. Working memory refers to a limited capacity system responsible for the temporary storage of information while engaging in processing activities (Baddeley, 2000; Baddeley & Hitch, 1974). A key component of Baddeley's model of working memory is the central executive, which is responsible for attentional control, higher-order processing activities, and for the coordination of activities within working memory (Baddeley, 1986). The central executive is supplemented by domain-specific slave systems: the phonological loop, which is responsible for the temporary storage and manipulation of verbal information; and the visuospatial sketchpad, which is responsible for the temporary storage and manipulation of visual and spatial material (Baddeley, 1992). The phonological loop comprises a capacity-limited phonological short-term store and a sub-vocal rehearsal process that refreshes and maintains phonological stimuli in the store for a brief period (Montgomery, 2002). Information in the phonological storage system is stored for a matter of seconds during which it decays, unless refreshed through sub-vocal rehearsal. The temporary storage of novel material in the slave systems allows the individual to create long-term representations of the material. The fourth component, the episodic buffer, is a storage system that links information from the components of working memory and long-term memory to form integrated units of visual, spatial and verbal information in time sequence (Baddeley, 2000). It is episodic in the sense that it holds integrated episodes or scenes, and a buffer in that it provides a limited capacity interface between systems using different codes (Baddeley, 2001). The multi-component model of working memory is illustrated in Figure 1.

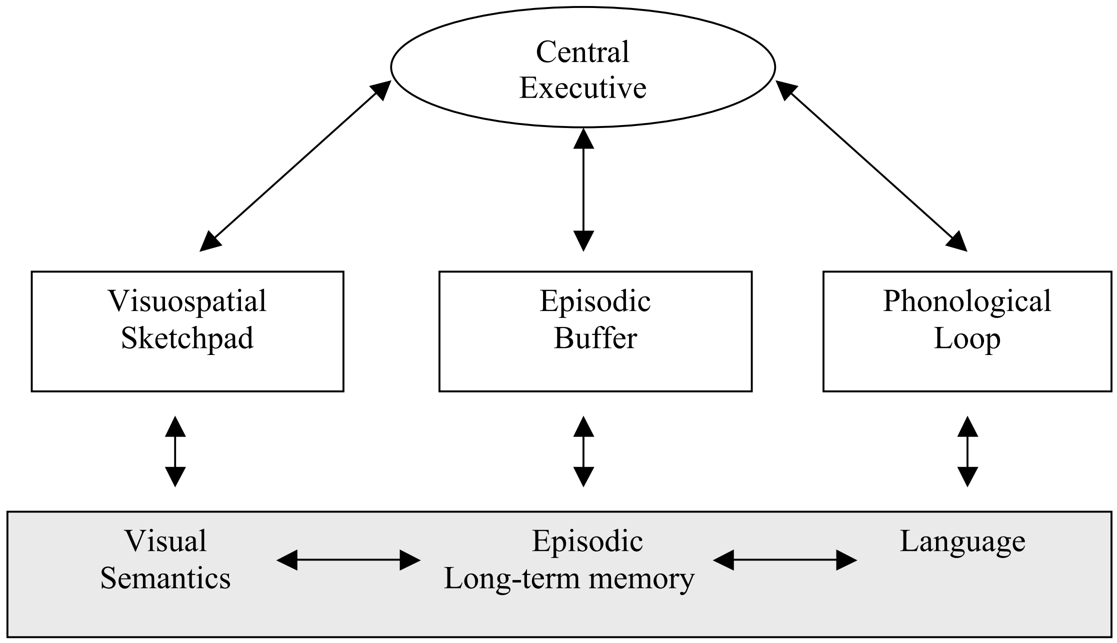

Figure 1. The multi-component model of Working Memory (Baddeley, 2000).

Working memory span, represented in Baddeley's model (Baddeley, 1986) by the phonological loop and visuospatial sketchpad, is assessed in tasks that simply require the relatively brief retention of information. Measures of the span of the phonological loop typically involve the serial recall of digits or words or the repetition of nonwords (Alloway, Gathercole, Willis, & Adams, 2004; Montgomery, 2003). Tasks assessing the span of the visuospatial sketchpad involve the retention of visuospatial information. An example of such a task is block recall, in which a series of blocks are tapped and the child is instructed to reproduce the tapped sequence.

Within the framework of Baddeley's (2000) working memory model, capacity refers to the ability to retain and refresh information for a brief period while the episodic buffer and central executive control various processing operations. Working memory capacity is typically assessed in tasks that require simultaneous storage and processing of information.

An example of a verbal working memory task is backward digit recall, in which the child recalls a sequence of spoken numbers in the reverse order (Pickering & Gathercole, 2001). Visuospatial working memory can be assessed by a task in which the child points to the colour of a series of crosses presented in a 3 x 3 grid immediately after each cross disappears, and then once all stimuli have been presented, points to the location where each of the crosses was presented (Adams & Gathercole, 2000). The episodic buffer is assessed by a repeating sentences task (Alloway, et al., 2004). Repeating sentences involves the integration of information from the phonological loop with knowledge from the long-term language processing system.

Although they used no assessment of the visuospatial sketchpad, Alloway, Gathercole, Willis, and Adams (2004) argued that the multi-component model of working memory (Baddeley, 2000) is structurally in place in 4 to 6-year-old children. Subsequently, Alloway, Gathercole, and Pickering (2006) explored the structure of working memory in 708 children aged 4 and 11 years. A confirmatory factor analysis revealed a three-factor model, with related but separate components representing the phonological loop, visuospatial sketchpad, and the central executive. Of note, the episodic buffer was not represented in their model. Overall, the structural organisation of working memory appears to be present in children as young as 4 years, although there is a development trend across childhood into adolescence (Luciana & Nelson, 1998, 2002). Alloway and colleagues (2006) documented an increase in working memory capacity as the children got older.

The model of working memory proposed by Carpenter and colleagues is characterised as a unitary system in which limited resources support both storage and processing functions (Daneman & Carpenter, 1983; Just & Carpenter, 1992). The model roughly resembles the central executive in Baddeley's model. Capacity is regarded as the maximum amount of resources available to support either storage or processing. A trade-off between storage and processing of information results when the resources available are exceeded by the demands of the task. For example, if processing demands of a task are high, resources allocated to maintaining old representations in an active state may be shifted to processing functions, causing one to "forget" some or all of the previously processed information. The total amount of resources available in working memory to support either of these functions varies among individuals. Whilst Baddeley's model of working memory has clear developmental implications for language learning and empirical data to support them, Carpenter and colleagues' model represents a "mature" adult-state working memory system (Montgomery, 2002). Thus, the bulk of knowledge about the relationship between memory and language acquisition in children comes from research conducted within the framework of Baddeley's model, and therefore, this model will be focused upon in this thesis.

In the following sections, research investigating the working memory abilities of children with SLI and RLTs will be discussed. Research focusing upon the span of the phonological loop will be discussed first, followed by research investigating performance of children with SLI and RLTs on visuospatial sketchpad tasks. Subsequently, studies examining performance on both verbal and visuospatial central executive tasks and dual-processing tasks will be discussed. Literature focusing upon performance on recalling sentences tasks, a measure of the episodic buffer, will conclude this chapter.

Phonological Loop in Children with SLI and Resolved Late Talkers

Using the framework of Baddeley's (2000) working memory model, the role of phonological memory in language development has been extensively studied (Conti-Ramsden, Botting, & Faragher, 2001). It is important in learning new words (Gathercole & Baddeley, 1989), as well as the ongoing storage of phonological, grammatical, and semantic knowledge. In the early stages of language development, toddlers must rely upon phonological memory to encode an acoustic-phonetic signal into a phonological representation and temporarily retain this representation in short-term memory. This allows for permanent phonological representations of words to be created in long-term memory. The phonological loop is also linked with other aspects of language processing including the formation of utterances and sentence processing (Baddeley, 1986; Montgomery, 1995).

In the SLI literature, phonological memory span is typically assessed by nonword repetition tasks, in which children repeat nonwords varying in length from one to five syllables (Gathercole & Baddeley, 1989; Laws & Bishop, 2003; Montgomery, 2003). To successfully repeat nonwords, one must maintain an acoustic representation long enough to support subsequent articulation. It is argued that nonword repetition is a robust and sensitive index of the capacity of the phonological loop as successful nonword repetition requires various phonological and memory-related processes, such as speech perception, encoding, storage, retrieval, and production (Montgomery, 2002, 2003). Recent literature has also highlighted that repeating a nonword is supported by a number of underlying skills, such as motor planning and articulation (Coady & Evans, 2008). Although nonword repetition for low word-like stimuli, such as *empliforvent*, taps phonological storage in a knowledge-free manner, repetition of high word-like stimuli, such as *glistering*, is additionally mediated by long-term lexical knowledge (Gathercole, 2006). The ability to repeat nonwords is significantly associated with the extent to which the stimuli resemble real words; nonwords that have a phonological or morphological structure similar to that of real words are easier to repeat than those that do not (Bishop, North, & Donlan, 1996; Gathercole, 1995).

Gathercole and Baddeley (1989) investigated the role of the phonological loop in the acquisition of vocabulary in 4- to 5-year old children with TLD. A group of 150 children were administered a nonword repetition task upon entering primary school at age 4 years and then a year later. Phonological memory, indexed by performance on the nonword repetition task, was significantly correlated with vocabulary knowledge at both ages. Of note, nonword repetition performance at age 4 years was predictive of vocabulary abilities at age 5 years. Gathercole and Baddeley proposed that phonological memory might mediate the long-term storage of phonological information, which is involved in vocabulary development. This research also found a general decline in repetition accuracy as the length of nonwords increased from two to four syllables. This performance pattern has been interpreted to reflect the limited capacity nature of the phonological loop (Montgomery, 1995).

Given that phonological memory is important in the development of language, particularly, vocabulary acquisition, investigations of working memory in SLI have focused almost exclusively on verbal memory paradigms (Ellis Weismer et al., 1999; Montgomery, 2000). Substantial evidence for a verbal storage deficit in SLI is provided by research using a nonword repetition task (Coady & Evans, 2008; Gathercole & Baddeley, 1990). Children with SLI consistently perform poorer on nonword repetition tasks than age-matched children with TLD (Briscoe & Rankin, 2009; Laws & Bishop, 2003; Montgomery & Evans, 2009; Nickisch & von Kries, 2009). They seem to have difficulty maintaining the phonological sequence of novel words long enough to establish the links between phonological representations, acoustic input, and articulatory patterns (Evans, Alibali, & McNeil, 2001). Children with SLI aged 4 to 9 years have been shown to have significantly greater difficulty repeating three- to five-syllable nonwords than one- and two-syllable nonwords, compared to typically developing children (Bishop, et al., 1996; Conti-Ramsden, 2003; Dollaghan & Campbell, 1998; Gathercole & Baddeley, 1990; Laws & Bishop, 2003; Montgomery, 1995). Poorer repetition of long versus short items reflects the capacity-limited nature of the phonological loop and, consequently, the diminished phonological capacity in SLI. Poor nonword repetition may be attributable to difficulties in encoding phonological representations and maintaining these representations in working memory. As argued by Montgomery (Montgomery, 2002), such findings provide further support for the view that phonological memory supports lexical acquisition.

Graf Estes, Evans, and Else-Quest (2007) conducted a meta-analysis of 23 published and unpublished studies that investigated nonword repetition performance in children with SLI. Children with SLI performed, on average, 1.27 standard deviations below typically developing children. Furthermore, children with SLI performed significantly poorer than children with TLD when repeating all nonword lengths, with greater deficits on three- and four-syllable items than on one- and two-syllable items. Of note, Graf Estes and colleagues found significant variability of findings across the type of nonword repetition task used. Across studies, four different nonword repetition tasks were used, including the Children's Test of Nonword Repetition (CNRep; Gathercole & Baddeley, 1996) and the Nonword Repetition Test (NRT; Dollaghan & Campbell, 1998), with each measure yielding a different effect size. This suggests that these tasks are not interchangeable and the differences in effect sizes may be due to different test characteristics, such as nonword length, articulatory complexity, and wordlikeness (Graf Estes, Evans, & Else-Quest, 2007).

It has been argued that limited span of the phonological loop in children with SLI compromises their ability to comprehend lengthy sentences. Montgomery (1995) investigated the relationship between phonological memory and sentence comprehension in a group of school-age children with SLI. It was proposed that as sentences get longer, the children are less able to store and process all the verbal information presented, thereby limiting their understanding of the sentences. The children completed a picture-pointing sentence comprehension task and a nonword repetition task. The sentence comprehension task included two sets of 20 sentences each corresponding to a set of linguistically redundant (longer) sentences (e.g., “The girl who is smiling is pushing the boy”) and a set of linguistically nonredundant (shorter) sentence (e.g., “The girl smiling is pushing the boy”). After hearing a sentence, the children were asked to point to the picture best matching the sentence. Children with SLI comprehended fewer longer sentences than shorter sentences relative to themselves and compared to children matched for receptive syntax knowledge. Interestingly, a positive relationship was found between performance on the nonword repetition task and the sentence comprehension task.

Given the consistent findings, nonword repetition may serve as an important predictor of language ability, if not a reliable clinical marker for SLI, as argued by Dollaghan and Campbell (1998), Bishop, North, and Donlan (1996), and Nickisch and von Kries (2009). Ellis Weismer et al. (2000), using a large population sample of children aged 7;1 to 8;11 years (*n* = 581), demonstrated that poor nonword repetition could assist in the identification of children with SLI. Nonword repetition performance proved to be a less culturally biased measure of language skills than other commonly used standardized measures (Graf Estes, et al., 2007). However, on its own, nonword repetition is not sufficient for a classification of SLI, since poor nonword repetition performance is not unique to SLI. For example, children with more global intellectual disabilities, such as Down Syndrome also perform poorly in these tasks (Conti-Ramsden, et al., 2001).

Deficits in phonological memory tasks in children with SLI compared to same-aged children with TLD have also been found with regard to digit span recall (Archibald & Gathercole, 2007a; Briscoe & Rankin, 2009; Hick, Botting, & Conti-Ramsden, 2005a; Hoffman & Gillam, 2004; Nickisch & von Kries, 2009; Norbury & Bishop, 2002) and real words (Briscoe & Rankin, 2009). Impaired performance on digit recall and word list recall tasks have been documented for children aged from 3 to 10 years.

Consistent with patterns of performance in children with SLI, children with resolved language impairments or delay have also demonstrated significant deficits in nonword repetition. Stokes and Klee (2009) explored the clinical utility of two versions of a new Test of Early Nonword Repetition (TENR) with 172 children aged 24- to 30-months. Based on their CDI total vocabulary score, the children were classified as late talkers or typically developing. The late talkers scored below the 16th percentile (1 standard deviation below the mean) on the CDI total vocabulary score or had no word combinations. The two versions of the TENR differed in that one contained 12 one- to three-syllable nonwords, whilst the other contained 16 one- to four-syllables nonwords consisting of early developing consonants and tense vowels. The one- to four-syllable test demonstrated superior diagnostic accuracy, with late talkers being approximately 15 times more likely to score below the 16th percentile than children with TLD. However, given the small sample size for the late-talking group, resulting in large confidence intervals, further research is needed.

Bishop and colleagues (1996) administered the CNRep (Gathercole & Baddeley, 1996) to children aged 7 to 9 years who had received regular speech-language therapy for at least one year and were no longer language impaired. The children demonstrated impaired performance on the nonword repetition task relative to children with TLD. The researchers proposed that nonword repetition may provide a sensitive index of a persistent underlying deficit in children who have used compensatory strategies to achieve adequate levels of language functioning. Similar results have been documented in studies with 4-year-old children who were classified as late talkers at 16 months, 5 ½ year olds who were identified as late talkers at 2 years and with 11-year-old children with a documented history of SLI, but whose more overt language difficulties had resolved, in that they had performed in the normal range on language measures or were no longer classified as language impaired (Conti-Ramsden, et al., 2001; Ellis Weismer, 2007; Ellis Weismer et al., 2000; Thal, Miller, Carlson, & Vega, 2005). These findings suggest that if a child achieves high scores on a nonword repetition task they are more likely to have higher language scores than if they had low scores on a nonword repetition task. Overall, the underlying deficit in phonological memory in children with a history of language impairment remains, but children learn to compensate for it. Thus, a deficit in nonword repetition performance is unlikely to be simply a secondary consequence of weak vocabulary or poor syntactic competence (Bishop, et al., 1996).

Visuospatial Sketchpad in Children with SLI and Resolved Late Talkers

Visuospatial memory is assumed to play a key role in acquiring semantic knowledge of concrete objects and their usage as well as for learning to combine visual imagery with the corresponding semantic-lexical component (Baddeley, 2003). However, performance of children with SLI on corresponding visuospatial memory tasks has been less extensively investigated (Archibald & Gathercole, 2007a), and research has not established whether the memory deficits in SLI are limited to the auditory-verbal memory domain or are characterised by more general memory impairments (Nickisch & von Kries, 2009).

Archibald and Gathercole (2006a) recruited a small sample of 15 children with SLI from language units and special schools across a wide age range, 7 to 12 years, and compared their performance to that of age-matched and language-matched typically developing children on measures of the visuospatial sketchpad. Of note, visuospatial central executive tasks were also included in this study; findings relating to these tasks will be discussed in the next section. Children with SLI performed at least 1.25 standard deviations below the mean on two of four (receptive and expressive) language measures, including one receptive measure, and equal to or greater than a standard score of 85 on a measure of nonverbal reasoning, Raven's Coloured Matrices (Raven, Court, & Raven, 1986). A dot matrix task provided a measure of the visuospatial sketchpad; a sequence of dots was presented on a grid, and after they had all been presented, the child pointed to the positions in the same order in which they had appeared. On this task, Archibald and Gathercole found that the performance of children in the SLI group was comparable to that of the age-match group and significantly better than that of the younger language-matched group, suggesting that children with SLI do not have impaired visuospatial memory.

In contrast to the above findings, Bavin, Wilson, Maruff, and Sleeman (2005) provided evidence to suggest that the memory limitations in SLI are not restricted to verbal memory. The performance of 21 children with SLI aged 4- to 5-years (mean age 4;5) was compared to that of age-matched typically developing children on a series of visuospatial memory tasks. The children with SLI, recruited from a participant registry or from local Maternal and Child Health Centers, scored at least 1.25 standard deviations below the mean on the Expressive or Receptive scales of the Clinical Evaluation of Language Fundamentals – Preschool (CELF-P; Wiig, Secord, & Semel, 1992) and performed within the normal range on three performance subtests of the Wechsler Preschool and Primary Scale of Intelligence – Revised (WPPSI-R; Wechsler, 1989). All children with SLI had low scores on expressive language, with 12 children meeting the criterion for SLI on the Expressive scale, seven meeting the criterion on both the Expressive and Receptive scales, and two children meeting the criterion on the Receptive scale, but also with a low Expressive score (85).

The experimental tasks used by Bavin and colleagues (2005) were from the Cambridge Neuropsychological Test Automated Battery (CANTAB; CeNeS_Ltd., 1999) and are appropriate for children aged as young as 4 years. These computer tasks required touch screen responses. Children with SLI had shorter spatial spans, such that they were less able than their peers to remember the order in which blocks changed colour and performed significantly poorer than their peers on pattern recognition, a task in which children had to identify a pattern previously presented on the computer screen. In addition, in a paired associative learning task they were less able to remember in which boxes patterns had appeared. There were also significant group differences for the first block of trials (10 trials) testing spatial recognition, a task in which the locations of blocks that had appeared on the screen had to be identified. As the patterns in the tasks were abstract, and thus difficult to label, children needed to remember the pattern without the help of verbal rehearsal. Therefore, poor performance on these tasks indicates a problem with nonverbal memory for children with SLI (Bavin, et al., 2005). Discrepancies between the two aforementioned studies may be due to differences in task types and age ranges. For example, one strong factor for the differences in visuo-spatial working memory tasks may be the involvement of the central executive. The differing task demands may explain, at least in part, the inconsistencies among results.

Nickisch and von Kries (2009) extended the findings of Bavin et al. (2005) documenting that 9-year-old children with expressive-receptive SLI had reduced visual span compared to typically developing children. In this study, children with SLI were less able than their peers to recall the order in which different abstract symbols were presented. Correlational analyses also revealed a significant strong association between visual memory span and receptive language quotients. Furthermore, in a longitudinal study conducted by Hick, Botting, and Conti-Ramsden (2005a), performance on a visuospatial span task was compared in nine children with SLI and nine age-matched typically developing children. The children with SLI were recruited from speech and language therapy services and were all receiving therapy throughout the study. The children scored at least 1 standard deviation below the mean on an expressive language measure and six of the nine children also scored less than 1 standard deviation below the mean on the receptive language measure. The children aged 3;4 to 4;5 years at the study onset were tested on three occasions, with a six month interval between each assessment. In each session, children completed a pattern recall task, in which they were asked to remember the locations of sharks positioned on a grid. Children then viewed a blank grid and were asked to point to the squares of sea in which the sharks had previously appeared. Although the typically developing children showed improvement on this task over the one year period, the children with SLI did not, indicating a delay in the development of visuospatial memory span.

To the author's knowledge, no study has investigated the performance of children with an early language delay but who have resolved on visuospatial sketchpad tasks.

Central Executive: Complex Working Memory Abilities in Children with SLI and Resolved Late Talkers

Deficits have been reported for children with SLI in central executive tasks, in which children are required to engage in a processing activity and retain some information for subsequent recall (Archibald & Gathercole, 2007a). The central executive is assumed to play an important role in the development of language. During the process of establishing semantic stores in long-term memory, the central executive regulates the flow of information processing between the subsystems, whilst coordinating selective attention. After exposure to repetitive combinations of sensory stimuli, the central executive responds by regulating the long-term storage of this information. It is the phonological or visual representations of this information in semantic networks that is the basis of language development (Hoffman & Gillam, 2004).

In addition to the visuospatial sketchpad task discussed in the previous section, Archibald and Gathercole (2006a) administered three visuospatial central executive tasks to 15 children with SLI, 15 age-matched children and 15 language-matched children, all aged between 7;3 to 12;5 years. One example is the odd-one-out task, in which a child views three boxes, each containing a complex shape. The child points to the shape that does not match the others and remembers its location. After all of the trials, the child then points to the blank boxes in the correct sequence in which the odd shapes had appeared. This type of task is often referred to as a dual-processing task as children must simultaneously hold information in mind while processing incoming information with selected task components varied across the verbal and visual domains. On all three visuospatial central executive tasks, the performance of the children with SLI did not significantly differ from that of the age-matched typically developing children and on one task the children with SLI performed significantly better than the language-matched younger children. From this research, it was concluded that children with SLI are largely unimpaired when processing and storage is confined to the visuospatial domain.

In contrast, Marton (2008) reported that the difficulties children with SLI show in working memory tasks are not restricted to the verbal domain. Marton demonstrated that a group of 40 children aged 5;3 to 6;10 years with SLI performed poorer than a group of 40 age-matched children with TLD in three visuospatial working memory tasks: space visualization, position in space, and design copying. All three tasks place high demands on central executive functioning as they require simultaneous storage and processing of visuospatial information.

Adopting a dual-processing paradigm, Hoffman and Gillam (2004) investigated central executive functioning in 24 children with SLI. All children with SLI performed at least 1.3 standard deviations below the mean on two or more subtests of the Clinical Evaluation of Language Fundamentals – Third Edition (CELF-3; Semel, Wiig, & Secord, 1995) and demonstrated nonverbal cognitive abilities within the normal limits. Six of the children with SLI demonstrated expressive impairments, while the remaining 18 children demonstrated mixed receptive and expressive language impairments. The children, aged 8 to 10 years, were assessed on the recall of spatial and verbal information and on a secondary task of colour identification to investigate information processing abilities. In the verbal recall (baseline) condition, the child recalled a set of numbers that had appeared on a computer screen. In the second condition, the child named the colour of each number during presentation, and then recalled the set of numbers; in the third condition, the child pointed to the colour of each number during presentation, and then recalled the set of numbers. In the spatial recall (baseline) condition, the child saw crosses appear on a computer screen, and after they had all been presented, he/she pointed to the locations that they had appeared in. In the second condition, the child named the colour of each of the crosses before pointing to the locations, and in the third condition, the child pointed to the colour of each of the crosses before pointing to the locations.

Across both verbal and spatial domains, children with SLI recalled less information than their typically developing peers (Hoffman & Gillam, 2004). The weakest SLI performance occurred when the spatial recall task was paired with the pointing (spatial) colour identification task. For both groups, children recalled more information when the modalities of the recall condition and colour identification task crossed (verbal recall paired with pointing colour identification, or visa versa), but this effect was greater for the typically developing children. Hoffman and Gillam suggest that children with SLI have greater difficulty than their peers with the coordination of information storage, retrieval and response output across both verbal and spatial domains. Therefore, memory limitations extend beyond the parameter of verbal processing; children with SLI have smaller storage capacities for both verbal and nonverbal information.

Archibald and Gathercole (2006b) investigated the extent to which deficits in working memory co-occur in a group of 20 children with SLI aged 7 to 11 years. Identification of SLI was based on two tests of vocabulary and a receptive grammatical task, but there was no measure of expressive language. Verbal and visuospatial memory span (storage only: measures of the phonological loop and visuospatial sketchpad) and working memory capacity (storage and processing: measure of the central executive) were assessed with tasks from the Working Memory Test Battery for Children (WMTB-C; Pickering & Gathercole, 2001), which provides multiple assessments of all components of Baddeley's model of working memory, except the episodic buffer, and is appropriate for children aged 4 to 11 years. The digit recall, word list recall, and nonword recall tasks served as measures of the phonological loop. The visuospatial sketchpad was assessed by three tasks, one of which was block recall. Additionally, the central executive was assessed by three tasks, one of which was backward digit recall. The standardized measure of backward digit recall is sensitive to the concurrent functions of verbal storage and processing given that the child must retain a series of digits while simultaneously rearranging and recalling them in reverse order (Montgomery, 2003). Scores on the tasks were summed to compute verbal memory span and visuospatial memory span composite scores, and a complex working memory composite score.

Archibald and Gathercole (2006b) reported deficits in 14 of the 20 children with SLI on the composite measure of verbal memory span. A "deficit" was defined as a score of more than 1 standard deviation below the mean of the standardised sample. Substantial deficits were also found on the composite measure of complex working memory (measure of the central executive) in the majority of children (95%; 19 of 20 children), replicating past findings (e.g., Ellis Weismer, et al., 1999). Although performance was markedly poorer on the counting recall task, in which children counted the number of dots presented and then recalled the dot tallies in the order of presentation, than on the other central executive tasks, composite scores were used in the analyses rather than individual scores for each test. Using composite scores may have missed specific problems experienced by children with SLI, as different tasks may have tapped different areas of cognition. For example, Archibald and Gathercole (2006a) found that one measure of visuospatial working memory, in which children judged whether two male figurines were holding a ball in the same hand and then remembered the position of the ball, correlated with nonverbal cognitive ability, whilst two other measures did not. Such differences in task specific results may be important in establishing profiles for RLTs and children with SLI.

More recently, Archibald and Gathercole (2007a) investigated processing and storage abilities of both verbal and visuospatial material by 14 children with SLI aged 7- to 12-years and two groups of typically developing children, matched on age or language abilities. Children with SLI, recruited from language units and special schools, performed at least 1.25 standard deviations below the mean on two of four language measures, including one receptive measure. Over three 30-minute sessions, the children completed two processing (verbal and visuospatial) tasks, two storage (verbal and visuospatial) tasks, and four dual processing tasks, which they termed complex memory tasks. These tasks were formed by combining the processing and storage tasks. The verbal processing task required children to point to squares of colours corresponding to spoken items (e.g., banana) and the visuospatial processing task required children to point to large squares with bevelled edges as quickly as possible. Processing speed was assessed in these tasks. The verbal storage task was a digit span task in which sequences of digits were presented visually, whilst the visuospatial storage task was a block recall task. An example of a dual-processing task is the visuospatial processing, verbal storage task in which children were required to locate the squares with bevelled edges and then to identify the target number within the squares and remember the sequence of numbers for later recall.

Archibald and Gathercole (2007a) found that children with SLI were significantly slower and less accurate on the two processing tasks (visuospatial and verbal) than the age-matched group. They performed comparably to the language-matched group once nonverbal ability and age was controlled for. In contrast, on both the verbal and visuospatial storage tasks, performance of the SLI group was similar to that of the age-matched group and significantly better than that of the language-matched group. On the dual-processing tasks, the performance of the SLI group was not significantly different from that of the age-matched group across task conditions. However, when the data were collapsed across processing domains, the SLI group was significantly impaired relative to the age-matched group on the dual processing tasks requiring verbal but not visuospatial storage. That is, the children with SLI had difficulty temporarily storing phonological representations of material whilst engaging in any type of concurrent information processing. The authors proposed that the generalised slowing hypothesis (Kail, 1994; Miller, Kail, Leonard, & Tomblin, 2001) provides a plausible explanation for the observed domain-general SLI deficit in speed of processing. Recall that according to this model, regardless of task nature or modality, children with SLI have limitations in speed of processing, that is, they are significantly slower than age-matched typically developing children in performing tasks. However, slow processing alone cannot explain the SLI deficit in the dual-processing tasks, as SLI performance on tasks involving visuospatial storage was comparable to that of the age-matched group. Therefore, Archibald and Gathercole suggested that the combination of both a domain-general slowing in processing with a verbal storage deficit underlies the poor performance of children with SLI on the dual-processing task involving verbal storage. This proposal is consistent with the well-documented impairments in central executive and phonological loop functioning in SLI.

Once again, to the author's knowledge, no study has investigated the performance of children who are RLTs on measures of the central executive.

Episodic Buffer in Children with SLI and Resolved Late Talkers

The episodic buffer is a recent addition to Baddeley's model of working memory, and thus research investigating the episodic buffer in children with SLI is limited. Repeating sentences is regarded as a measure of the episodic buffer and is appropriate for children as young as 4 years (Alloway, et al., 2004). Repeating sentences requires the integration of temporary representations of sentences from the phonological loop with semantic and syntactic information from the language processing system. That is, the episodic buffer integrates representations from working memory, long-term memory, and language processing systems.

Conti-Ramsden, Botting, and Faragher (2001) demonstrated the potential of using repeating sentences as a clinical marker for the identification of SLI. In a sample of 160 11-year-old children, there was a high level of accuracy (88%) in identifying children with SLI on the basis of their sentence repetition performance. Consistent with this, Norbury and Bishop (2002) and Laws and Bishop (2003) found children with SLI aged 6- to 10-years and 4- to 7-year olds, respectively, had significantly lower scores than children with TLD on a recalling sentence task. RLTs have also been found to have poorer accuracy on sentence repetition tasks than their age-matched peers (Bishop & Adams, 1990). A group of 53 children who were identified as late talkers at 2 years, based on a parent report measure of language development, scored within the normal range on the standardised language measure, TOLD-P:3 (Newcomer & Hammill, 1997), at 5 ½ years, but significantly poorer than children with TLD on a sentence imitation task (Ellis Weismer, 2007). Conti-Ramsden et al. argue that performance on sentence repetition could identify the majority of children whose current language status falls in the normal range despite a history of language impairment. To the author's knowledge, no published research has directly compared the performance of children with SLI and RLTs on a repeating sentences task.

Summary

A review of the literature in SLI reveals that this group of children has impaired performance on a variety of working memory tasks. Studies of SLI consistently report significantly lower scores than for children without language impairment, particularly in those verbal working memory tasks that require simultaneous processing and storage of information. As language comprehension and expression rely on the ability to actively maintain and process incoming verbal material, verbal working memory is involved in the acquisition and processing of language. Thus, poor verbal working memory abilities will impact negatively on an individual's language abilities. Furthermore, children with SLI consistently demonstrate impaired performance on a measure of the episodic buffer; repeating sentences. Performance on corresponding visuospatial working memory tasks has been less extensively investigated and there are discrepancies across findings. Overall, the evidence of a deficit in memory in SLI is of sufficient magnitude to suggest a primary role in the developmental language disorder (Archibald & Gathercole, 2006a; 2006b; Ellis Weismer, et al., 1999). However, there is limited research investigating working memory abilities of children who were late talkers but recovered, and research comparing the memory profile of these children with that of children with SLI and typically developing children. The limited amount of research available on RLTs suggests a deficit in verbal working memory. Study One, discussed in Chapter 5, was designed to add to this area of research.

CHAPTER 4

NARRATIVE ABILITIES OF CHILDREN WITH SPECIFIC LANGUAGE IMPAIRMENT AND RESOLVED LATE TALKERS

Tasks requiring children to generate and recall verbal narratives on the basis of sets of pictures serve as ecologically valid and educationally relevant instruments to assess children's expressive language skills (Fey, Catts, Proctor-Williams, Tomblin, & Zhang, 2004; Redmond, Thompson, & Goldstein, 2011). This applies in clinical settings and in research into the development of communicative and literacy skills among both typically developing children and children with atypical language development (e.g., Berman & Katzenberger, 1998; Botting, 2002; Justice, Bowles, Pence, & Gosse, 2010). By definition, a narrative refers to the production of a fictional or real account of an experience or event that is temporarily sequenced (Engel, 1995). Narratives are generally thought of as a type of discourse, as they involve the production and comprehension of multiple sentences or utterances that unfold over time (Justice, et al., 2010). Narratives from children correspond closely to skills involved in everyday spontaneous speech and require the integration of linguistic and non-verbal cognitive abilities (Berman & Katzenberger, 1998; Botting, 2002; Norbury & Bishop, 2003). Additionally, understanding narrative structures requires children to store information in memory in order to identify relationships across utterances, to integrate incoming information that adds to or modifies current information, and to discard information that is irrelevant or no longer needed (Boudreau, 2007). These processes allow children to build an integrated and coherent model that includes various elements (characters, events, actions, and mental states of characters) temporally and causally arranged into an overall plot (Montgomery, Polunenko, & Marinellie, 2009).

Oral narratives are fruitful in providing a vast amount of information about the child's linguistic, cognitive, and social abilities (Capps, Losh, & Thurber, 2000; Norbury & Bishop, 2003). Much research attention has been directed to children's understanding of the global or hierarchical structure of the narrative, the cohesion of narratives, local sentence structure, and children's use of evaluative devices. In this chapter, developmental perspectives of children's narrative abilities and research investigating each of these aspects of narrative production in typically developing children will be discussed. This will be followed by a review of the literature investigating the narrative abilities of children with SLI and RLTs, and the relationships between these abilities and working memory.

Narrative Skills in Typical Development

Narrative Abilities: Developmental Perspective

Clear developmental trends have been shown in narrative skills. Berman and Katzenberg (1998) investigated the development of narrative abilities and documented three levels of narrative skills: pre-narrative, local narration, and global action-structure. Each level is characterised by how the child integrates and organises the main story elements into a discourse. Children in the "pre-narrative" level tend to produce narratives that show no obvious connection to the content of the pictures or describe each picture in isolation, whilst children in the "local narration" level, produce narratives in a linear, temporal fashion, linking individual pictures to one another. Children in the highest level ("global action-structure") produce narratives that include temporal sequences, which are constructed according to a hierarchical, organised global structure. There are three essential elements of global structure: the initiating goal or problem that motivates the action of the story, the attempts to achieve the goal, and the overall outcome.

Berman and Katzenberg (1998) found that with increasing age, children tend to move through these three levels. They presented 144 Israeli Hebrew speaking preschool children aged 4-6 years, 24 children aged 10-11 years and 12 adults with two series of four pictures depicting a sequence of events. The pictures depicted an initial problem or goal, attempts to meet this goal or deal with this problem, and a resolution of the problem or attainment of the goal. No 4-year-old child and a minority (5.5%) of 5-year-old children produced narratives that were organised around an overall action-structure, with an initial goal, actions aimed at meeting that goal and a resolution. In contrast, approximately half of the narratives produced by 6-year-old children showed an action-structure type of organisation and all the 10-year-old children and adults organised the events in their narratives with an initial goal, aims at meeting that goal, and a resolution. A developmental trend was also documented in the children's ability to introduce, maintain and distinguish reference to different characters in the narratives, with 15% of the 4-year-old children maintaining reference to each character across the series of pictures, compared to 23% of the 5-year-olds and 44.3% of the 6-year-olds.

In narrative production, the linguistic form of a referent (e.g., definite noun, pronoun) is determined by the overall global and local structure of the narrative and the linguistic function of the referent. The linguistic function for the referent may be to introduce a main or subsidiary character in the story or to reintroduce or maintain reference to the character. Children's ability to use appropriate referential expressions to introduce and follow characters as the story develops influences the cohesiveness of the narrative (Van Der Lely, 1997).

There are a number of cohesive devices that can be used to make connections between sentences that comprise a story. Karmiloff-Smith (1985) investigated the use of cohesive devices in narrative generation in a large sample of 4- to 9-year-old typically developing children. A developmental sequence of three levels was documented, consistent with a U-shaped behavioural pattern. In level one, young children's production of narratives was found to be stimulus-driven; the stories of children aged 4 to 5 years accurately reflected what was in the physical stimulus of each picture. However, their use of nominal determiners (e.g., definite articles) was found to be dependent on the particular isolated event or character. For example, Karmiloff-Smith found children of this age to introduce the main character with a definite noun (e.g., *the boy*) and then continue to refer to all characters (main and subsidiary characters) with a string of pronouns (e.g., *he*), therefore making it difficult to distinguish between different characters. At this early stage of narrative development, Karmiloff-Smith suggests that the child's primary goal is to match as closely as possible the pictorial stimuli. In level two, typically at the ages of 6 to 7 years, children demonstrated gains in the intralinguistic linking of the sequence of events. The main characters were introduced with indefinite articles (e.g., *There is a boy*) and the use of pronouns was largely restricted to the maintenance of the main character in the story. That is, their sentences followed a pattern such as, *There's a boy and he is walking to the ice-cream shop and he is ordering an ice-cream and then he eats it*. However, by imposing a rigid "thematic subject constraint", children temporarily produced impoverished descriptions of the storybook pictures. By 8 to 9 years, children were becoming aware of the more global aspects of a story, integrating them with local aspects as they organized them in terms of episodes. Typically, children of this age were able to produce narratives that were rich in both detail and linguistic structure due to the use of differential markers to denote the discourse roles of the characters. At level three, the thematic subject constraint was still held, but it was applied less rigidly. For example, once the main character was introduced with an indefinite article, it was consistently referred to with a pronoun, whereas a definite noun (e.g., *the lady*) was used to refer to the subsidiary characters.

Wigglesworth (1990) used two picture books to elicit narratives from 60 children of 4, 6 and 8 years of age and 20 adults. Book One consisted of eight pictures, in which no single character could be easily identified as the main protagonist, while Book Two had 10 pictures and was designed to encourage the development of a thematic subject. These narratives were examined for developmental trends in maintaining and switching reference. The results demonstrated an increasing tendency with age to introduce the main character with a full noun phrase. For example, when introducing the first character in Book One, 5% of the 4-year-old children used a noun, in comparison to 50% and 70% of the 8-year-old children and adults, respectively. The 4-year-old children predominantly used pronouns to introduce both main and subsidiary characters.

Studies of spoken narratives and their development have focused on different aspects. Some have explored the general, global characteristics of a narrative, such as a child's understanding of the event structure of narratives, the thematic organization of main ideas, and the use of evaluative devices, as in studies by Bamberg and Damrad-Frye (1991), Bishop and Donlan (2005), and Norbury and Bishop (2003). Others have concentrated on the specific linguistic characteristics used by children in the process of constructing a narrative (e.g., Gummersall & Strong, 1999), such as the number of complex sentences or the way in which specific cohesive devices (e.g., conjunctions) are used to link words and sentences (Reilly, Bates, & Marchman, 1998). The recall and comprehension of narratives has been the focus of some studies, with recall serving as a test of memory as children are required to recall the story as closely as possible to the original (Bishop, 2004; Dodwell & Bavin, 2008; Norbury & Bishop, 2002).

Overall, the examination of a child's spoken narrative can provide valuable information about skills in syntax, morphology, vocabulary, and phonology within a naturalistic discourse-level context. Furthermore, given the added element of the test of memory in the recalling and retelling of a narrative and the associations between working memory abilities and language impairments of children with SLI, the analysis of narratives provides a valuable approach to understanding children's knowledge and use of language.

Complex Sentence Structure in Narratives

The analysis of children's complex sentence structure when generating a narrative provides valuable information regarding syntactic skills (Gummersall & Strong, 1999). Complex sentences serve to indicate relations between main events and subordinate, background events (Manhardt & Rescorla, 2002) and according to Berman and Slobin (1994), complex subordinate (dependent) clauses enhance the overall quality of the narrative from the point of view of the listener. In addition, as children begin discussing characters' actions and consequences, complex clauses are necessary.

Syntactic complexity develops at the clause level by coordination or subordination. When coordinating or linking clauses, the clauses are related semantically and the syntactic status of both clauses is equal; for example, *The girls came and their dolls peeked out*. In subordination, clauses are embedded into or attached to a main clause (Scott, 1988a). Gummersall and Strong (1999) discussed the three major types of clause subordination:

- Adverbial clauses occur as children describe temporal or cause-and-effect relationships for story events; for example, *When he got home*, *he took the toy out*;
- Nominal clauses. Complement clauses represent nominals; for example, *He wanted to buy a fish*;
- Relative clauses are used to modify nouns; for example, *The people who had the fish came to their house.*

In the preschool and early school years, adverbial clauses of time (*when*) and reason (*because*) are most commonly used, as well as nominal clauses (Gummersall & Strong, 1999).

Evaluative Devices in Narratives

Children as young as 5 years of age have been found to use evaluative devices in narratives elicited using wordless picture books. Evaluative devices serve to evaluate the narrative, helping to establish the causal links among events in the story (Bamberg & Damrad-Frye, 1991). They contribute to the coherence of the narrative by giving meaning to the individual events and actions. Evaluative devices also represent the narrator's interpretation of events, such as the mental state of characters. Bamberg and Damrad-Frye (1991) focused on five types of evaluative devices, adapted from the work of Labov and Waletzky (1967) and Peterson and McCabe (1983). These five types are:

- Frames of mind, which includes references of character's feelings and mental state (e.g., *happy*, *sad*). This category also included emotional verbs, such as *scared* and *cross*, and mental states or activities, such as *think* and *want*.
- Character speech, which represents strategies for capturing and maintaining the listener's attention by adopting character perspective through direct speech (e.g., *I'd like one gold fish please*) or indirect speech of characters (e.g., *The boy asked his mum to ring the pet-shop*).
- Hedges, which are used to indicate a level of uncertainty or as a distancing device, and thus, imply multiple possible interpretations or perspectives of an event (e.g., *so he thought, <u>maybe</u> I'll see what I can do, <u>maybe</u> play a game*).
- Negative comments, which indicate some surprise or information that contradicts the child's expectations, such as, *…but it <u>wasn't</u> the fish*.
- Causal connectors, which include interclausal connectors such as *because*, *so* (e.g., *He got a bit hot, <u>so</u> he decided to get an ice-cream*).

Bamberg and Damrad-Frye (1991) found that the overall use of evaluative devices increased significantly with age, with adults using three times as many evaluative devises as

5-year-old children and two-and-a-half times as many as 9-year-olds. Although the 5- and 9-year-old children did not differ in the frequency of evaluative devices used, the types of evaluative devices used did change with age. Investigation into the pattern of usage revealed a similar pattern for the 9-year-old children and the adults, with both groups including more relatively sophisticated evaluative devices, such as references to “frame of mind” than the other types of evaluative devices. In contrast, the 5-year-old children showed no clear preference, using all devices equally. Further analyses into where particular evaluative devices were used in the narrative revealed a developmental pattern, with 9-year-old children using evaluative devices to highlight specific aspects of events or characters in the narrative, while adults’ references to evaluative devices, such as frames of mind, were motivated by their knowledge of how to characterize and signal the overall, hierarchical structure of the narrative.

Narrative Skills in Different Clinical Populations

Generation, Recall, and Understanding of Narratives in Children with SLI

A number of studies have investigated the abilities of children with SLI to generate and recall a narrative using a picture storybook (Bishop & Donlan, 2005) or to retell a story they have heard, sometimes using a series of pictures as a prompt (Dodwell & Bavin, 2008; Norbury & Bishop, 2002). Bishop and Donlan (2005) assessed the narrative abilities of 63 7- to 9-year-old children with SLI (34 children with receptive-SLI and 29 with expressive-SLI) and 32 typically developing children of the same age. Children with SLI scored more than 1.33 standard deviations below the mean on at least one of four (two expressive and two receptive) language tests. Performance of the three groups of children did not differ significantly on the measure of nonverbal IQ, the Raven’s coloured matrices (Raven, Court, & Raven, 1986). Children were shown two stories, each depicted in a sequence of five black and white photographs. One sequence of pictures depicted a car breaking down and the attempts of a man and a girl to go to a petrol station to get petrol for their car and return home. The other sequence of pictures depicted a family going to the park with their dog and while at the park losing their dog, only to find that the dog was waiting for them at their car. For each story, children were asked to generate a story based on the photographs and then 30 to 40 minutes later, without warning, recall the stories. The narratives were analysed in terms of content (e.g., main story ideas), structure (e.g., length of utterances and number of dependent clauses), and psychological content (e.g., use of cognitive state terms, such as references to feeling states, motivations, and communication). Bishop and Donlan found differing results for the expressive-SLI group relative to the receptive-SLI group. For initial-story telling, children with receptive-SLI provided fewer main story ideas, cognitive state terms, and dependent clauses than the typically developing children. Whilst children with expressive-SLI generated a similar number of main ideas, cognitive state terms, and dependent clauses compared to the typically developing children, they did produce shorter utterances. Upon recall of their own narratives, the children with receptive-SLI recalled significantly fewer main story ideas than both the typically developing children and children with expressive-SLI. Analyses revealed that children with receptive-SLI forgot a disproportionate amount of the story relative to the other groups. Bishop and Donlan provided evidence to suggest that children with SLI, particularly those with receptive language difficulties, have difficulty in encoding and remembering meaningful sequences of events.

Using various narrative tools, comprehension of language, particularly the ability to draw on information to make inferences, has been investigated in children with SLI. Inferencing refers to the abstraction of information that is not explicitly presented. It is essential to early language learning and competent conversational skills (Botting & Adams, 2005). Research in this field has demonstrated that, compared with age-matched and language-matched typically developing children, children with SLI have significant difficulty with both literal (sometimes referred to as factual) and inferential questions (Bishop & Adams, 1992; Crais & Chapman, 1987; Ellis Weismer, 1985). Norbury and Bishop (2002) assessed the comprehension abilities of 16 6- to 10-year-old children with SLI and 18 age-matched children with TLD and looked at the relationship between inferencing skills in story comprehension and story recall. All children with SLI scored at least 1 standard deviation below the mean on two or more standardised language assessments and achieved a scaled score of 80 or above on a measure of non-verbal ability. Children were read five stories by the examiner and after each story they were asked six comprehension questions: two literal (e.g., "Where was the clock?"), two involving "text-connecting" inferences (e.g., "Where did Michael get the orange juice?"), and two involving "gap-filling" inferences (e.g., "How did Debbie and Michael travel home?"). Text-connecting requires children to integrate information explicitly stated to link ideas, while gap-filling requires children to integrate their own general knowledge with information in the narrative to fill in details that are not explicitly stated. If the children gave an incorrect answer or failed to answer a question, graded prompts were given to assist them. After all of the comprehension questions were administered, the children were asked to recall the final story.

Children with SLI were found to have greater difficulty answering both literal and inferential questions than the children with TLD (Norbury & Bishop, 2002). Of note, both groups found the gap-filling inference type most difficult. Given the well-documented verbal memory deficits in SLI, Norbury and Bishop (2002) proposed that children with SLI have difficulty holding the story information in mind while at the same time processing the language of the questions, making adequate processing of stories and questions challenging. The two groups of children did not differ on story recall; however, the task used in this study may have aided memory. The children were asked to recall a story that they had heard only after being asked questions about it. If they had difficulty with the questions, they were given clues until they provided the correct answer. This procedure could have exaggerated children's recall of the story. Nonetheless, for the children with SLI, there was a strong positive relationship between story comprehension and recall. From these results Norbury and Bishop (2002) suggested that as children listened to these stories, they built an integrated mental representation of the story, which not only facilitated their understanding of the story, but also their memory of it.

Botting and Adams (2005) compared the inferencing abilities of 25 children with SLI (mean age of 10;11) with three groups of typically developing children (aged 7-, 9- and, 11-years). The 11-year-old children represented an age-matched group, whilst the two other groups provided younger comparisons with similar language abilities as the SLI group. All children with SLI achieved a performance IQ score of 70 or above. Each child completed an inferential comprehension task, in which the child listened to a story read aloud by the examiner whilst looking at the pictures. The child was then asked 20 inferential questions, to which they responded "true/yes" or "false/no". In this task, children with SLI performed more poorly than the age-matched typically developing children, but comparably with the two groups of younger children, suggesting that inferencing skills of children with SLI are in line with their language ability. Of particular interest, Botting and Adams re-ran the analyses with a subsample of children with SLI, children with a performance IQ of 85 or above (n = 17), and failed to find significant group differences. That is, children with SLI with a nonverbal IQ of or above a standard score of 85 were not impaired on inferential comprehension questions. As there was no measure of cognitive ability for the typically developing children, it was not possible to assess or control for differences in cognitive abilities across groups. Furthermore, limiting the generalisability of these findings, the authors noted near ceiling performance on the inferential questions due to the high probability of answering correctly by chance created by the two (true or false) response options.

In a pilot study, to examine the narrative skills of five 7- to 8-year-old children with SLI, Botting (2002) utilised the book, *Frog, Where are you?* (Mayer, 1969) to elicit narratives, in addition to the standardised narrative retelling task, *The Bus Story* (Renfrew, 1991). A storybook containing 24 pictures depicts the frog story; a story about a young boy and his dog as they engage in a search for the boy's missing frog. In the story, the dog and the boy encounter several animals during their search and eventually find a family of frogs, from which the boy selects a single frog to take home with him. The children were instructed to look through the wordless picture book silently and then tell the researcher the story, using the pictures as prompts. In *The Bus Story,* the children listen to a story told by the researcher, and are then asked to retell the story as close to the original as possible, with the pictures serving as prompts. The narratives were analysed for story structure, the use of evaluative devices, and linguistic characteristics (e.g., length). The evaluative devices were analysed based on Bamberg and Damrad-Frye's (1991) five-category system as previously discussed and story structure was assessed using a scheme adopted from Tager-Flusberg's (1995) scheme. This assesses whether the narrative included a formal opening, orientation to characters or setting, explicit mention of the theme, a resolution, and a formal ending.

For the retelling narrative task (*The Bus Story*), the mean information score for the SLI group was within the normal range for the children's age, but the mean number of subordinate clauses and mean sentence length was below the mean for age, based on standardised scores. Similarly, in the narrative generation task (*The Frog Story*), children with SLI told significantly shorter stories than typically developing children (Tager Flusberg, 1995) indexed by the total number of words. Botting (2002) also showed that the more information children recalled in a narrative recall task, the more likely they were to include relevant story structure elements when generating the narrative, but less likely to use evaluative devices. Botting suggested that evaluative devices, such as negatives, are used as alternative devices for children with SLI who cannot rely on their limited working memory capacity to generate a narrative. Holding a story structure in mind whilst producing the necessary linguistic structures may require a higher degree of working memory than using more immediate story features (i.e., evaluative devices). Therefore, it was suggested that to compensate for poor narrative generation, children with SLI make the story more interesting and exciting by using these tools.

Complex Sentence Structures in Narratives in Children with SLI

Gummersall and Strong (1999) assessed complex syntax in 12 8 to 11-year-old children with language impairment (Mean age 9.86 years) who were receiving language intervention services and 20 children with TLD. Children with language impairment performed at least 1 standard deviation below the mean on two or more measures of oral expression or listening comprehension in one or more of three areas: morphology, syntax, and semantics. All children had IQ scores of 85 or above. The narrative task was divided into three components. Children (a) listened to the story told by the examiner, whilst looking at the pictures, (b) listened to each sentence of the story in isolation and repeated each with the picture in view (sentence repetition task), and then (c) recalled the story in the absence of the pictures. As the two groups of children were not matched for age or IQ, statistical significance testing was not performed; rather descriptive statistics were presented. Children with language impairment produced slightly fewer words per T-unit (M = 8.80) and clauses per T-unit (M = 1.36), relative to children with TLD (M = 9.20, M = 1.45, respectively). A T-unit is “one main clause with all the subordinate clauses attached to it” (Hunt, 1965, p. 20). Children with language impairment also produced less complex stories (M = 10.50) than the typically developing children (M = 15.30) indexed by the number of subordinate clauses.

Cohesion of Narratives by Children with SLI

Van Der Lely (1997) investigated the linguistic abilities of 12 children with "Grammatical" SLI, aged 10;2 to 13;11, in a narrative discourse. Grammatical SLI was characterised by a "disproportionate impairment in the grammatical comprehension and expression of language" (Van Der Lely, 1997, p. 223). Children so defined demonstrate impaired production of inflectional morphology; that is, they omit obligatory third person agreement (-*s*) on the verb or make errors with both regular and irregular past tense marking. The research focused on the linguistic forms used to introduce, reintroduce, and maintain references to the two main characters in a narrative discourse. The narrative abilities of children with Grammatical SLI on the wordless storybook, *Frog, Where are you?* (Mayer, 1969), were compared to that of three groups of younger typically developing children, matched on morpho-grammatical abilities or expression and comprehension of single words. The mean ages of these groups were: Language control group 1, 6;8, Language control group 2, 7;10, and Language control group 3, 8;10. The results of the analyses revealed that the children with SLI provided a similar amount of information relative to the three groups of younger typically developing children. That is, children with SLI produced narratives of similar length and provided similar numbers of references to the main and subsidiary characters. In regards to their ability to use appropriate referential expressions, the children with SLI were able to differentiate between the linguistic forms of reference which presuppose the least knowledge of the listener from those which presuppose some knowledge. Consistent with a mature pattern of referencing, the children primarily used the indefinite article noun phrase to introduce a protagonist, the definite noun phrase to reintroduce the protagonist and the more presupposing pronoun or zero anaphor to maintain reference. Overall, the findings of Van Der Lely (1997) indicate that children with SLI, aged 10 to 13 years, have relatively mature linguistic abilities in the use of referential expressions to produce a cohesive, structured narrative discourse. This is consistent with the work of Berman and colleagues which indicates that at ages 9 to 10 years, children have generally mastered anaphoric referential strategies and are therefore able to introduce, maintain, and shift reference to characters in an appropriate and unambiguous fashion (Berman, 2009; Berman & Katzenberger, 1998).

Use of Evaluative Devices in Narratives in Children with SLI

Labov and Waletzsky (1967) argued that in addition to referential information about the characters and the sequence of unfolding events, narratives include evaluative information. That is, good narratives have a point, and particular evaluative devices reflect the narrator's perspective on the characters and their activities.

A number of researchers have investigated the use of evaluative devices in narratives produced by children with SLI. Norbury and Bishop (2003) examined the narrative abilities of 17 6- to 10-year-old children with SLI and 18 typically developing children of comparable age. Children with SLI were recruited from schools that specialised in the education of children with SLI and all scored at least 1 standard deviation below the mean on at least two standardised language assessments. Children were assessed on the narrative instrument, *Frog, Where are you?* (Mayer, 1969), as used by Botting (2002) in her study with children with SLI. Narratives were analysed according to their global plot structure, local linguistic structure, and the child's ability to provide evaluative comments. For global plot structure, children were awarded points for mentioning the initiating event, the attempts or actions aimed at resolving the problem, and a resolution. At a more local linguistic level, analysis focused on story length, the number of complex sentences used (e.g., subordinate clauses), the amount of relevant information conveyed, and cohesion. The evaluative comments were analysed based on Bamberg and Damrad-Frye's (1991) five-category system: frames of mind, negative comments, causal connectives, hedges, and character speech.

Norbury and Bishop (2003) found that children with SLI performed similar to the typically developing children on measures of global story structure, and conveyed a similar amount of information, indexed by the total number of morphemes and syntactic units used, but in a "simpler" fashion. That is, children with SLI made more tense errors and used less complex sentences than typically developing children. This finding is consistent with the view that difficulties with verb inflections are clinical markers for SLI (Laws & Bishop, 2003; Rice & Wexler, 1996). All children aged 6 to 10-years were sensitive to the listener's needs when introducing and maintaining referents to story characters, resulting in no significant group difference in total references. In addition, groups did not differ in their use of evaluative comments or the number of verbs produced, indexed by both verb tokens and verb types. Bamberg and Damrad-Frye (1991) documented that although children as young as 5 years referred to the mental and emotional states of characters in their narratives, this ability increased throughout childhood. Similarly, global structure measures may not be sensitive enough to distinguish language-impaired children from typically developing children in young children who are still in the process of developing narrative skills.

Johnston, Miller, and Tallal (2001) investigated the use of cognitive state terms (e.g., *think, knew, decide*) by children with SLI by comparing samples of their conversational speech to those of both language and mental age-matched typically developing children. "Language age" was calculated for each child by averaging scores from several tests of language ability: the Sequenced Inventory of Communicative Development, the Token Test, the Northwestern Syntax Screening Test, the Carrow Elicited Language Inventory, and the Arizona Articulation Proficiency Scale. The children with SLI demonstrated "language ages" that were at least one year lower than both their chronological and mental ages and had achieved an IQ score of at least 85. In contrast to the findings of Norbury and Bishop (2003), children with SLI aged 4;4 years used fewer cognitive state terms, as well as fewer types of such terms, than age-matched typically developing children. However, in comparison to younger typically developing language-matched children, aged 2;11 years, children with SLI used a comparable number of cognitive state terms and a similar diversity of such terms. Given that cognitive state verbs tend to be used more in complex sentences, Johnston et al. (2001) suggested that syntactic limitations might constrain children's learning and use of mental states. The inconsistent results from Norbury and Bishop and Johnston et al.'s research suggest that the different stimulus material used to elicit evaluative devices and the age range of children tested are important factors in revealing group differences.

Narrative Abilities and Working Memory in SLI

Recent research with children with SLI has explored the relationships between working memory and narrative abilities. As discussed in Chapter 3, children with SLI perform significantly poorer than typically developing children on various measures of the phonological loop, visuospatial sketchpad, central executive, and episodic buffer (e.g., Archibald & Gathercole, 2007a; Ellis Weismer, Evans, & Hesketh, 1999; Hick, Botting, & Conti-Ramsden, 2005a; Hoffman & Gillam, 2004; Montgomery, 2003). These memory deficits may limit the children's ability to form a coherent narrative when generating and retelling a story from a wordless picture book. In addition, narrative comprehension involves the co-ordination of storage and processing of incoming information and the reactivation and integration of large amounts of information (Montgomery, et al., 2009). The ability to keep track of many details in a story and integrate information from different pictures may prove challenging given the limited working memory abilities of children with SLI (Bishop & Donlan, 2005).

Montgomery, Polunenko, and Marinellie (2009) focused on the contribution of the phonological loop and central executive components of working memory to the understanding of spoken narratives in 67 typically developing children aged 6 to 11 years.

The children completed a digit span task and a Competing Language Processing Task (CLPT) adapted from the work of Gaulin and Campbell (1994); the Test of Narrative Language (TNL; Gillam & Pearson, 2004) was used to assess the children's story comprehension. The CLPT requires children to listen to sets of sentences judging the truth of each sentence and then at the end of the set, recall as many of the last words from each sentence as possible. In the TNL, children listened to two stories and at the end of each story they were asked to answer comprehension questions about the story, 19 of which were literal questions and four were inferential questions. Performance on the listening span task, a measure of the central executive, correlated with narrative comprehension after adjusting for the effects of age. This finding suggests that to achieve adequate understanding of narratives, children needed sufficient resources to temporarily store and process the information in the phonological loop, create links to the language system in long-term memory, and continually integrate information from these components to build a coherent mental model. The measure of the phonological loop (digit recall) did not correlate significantly with comprehension, suggesting that immediate verbal short-term memory did not play a key role in children's narrative understanding. Montgomery et al. argued that the process of building a mental model involves temporarily storing and integrating large chunks of verbal material, exceeding the limits of the phonological loop. Of note, this study did not investigate the role of the episodic buffer in the comprehension of narratives, and given the small number of inferential questions administered, the two types of comprehension questions were not investigated separately. The role of the central executive may differ for different types of comprehension questions.

Dodwell and Bavin (2008) investigated the associations between verbal working memory and the recall and comprehension of narratives in 6- to 7-year-old children with SLI. The phonological loop was assessed with digit recall and word list recall tasks. Recalling sentences was used as a measure of the episodic buffer, whilst the CLPT (Gaulin & Campbell, 1994) was used as a measure of the central executive. Two narrative tasks were administered: the Birthday Story (Culatta, Page, & Ellis, 1983) and the Fish Story from the Expression, Reception and Recall of Narrative Instrument (ERRNI; Bishop, 2004). The Birthday Story involved the researcher telling the child a story about a boy's birthday party and then the child recalling this story and answering some inferential and literal comprehension questions. In contrast, the ERRNI Fish Story examined narrative generation, recall, and comprehension. The child looked through a storybook containing 15 pictures before generating a story and then, after a 20-minute delay, was asked to recall the story and answer a series of comprehension (literal and inferential) questions.

Whilst the children with SLI performed significantly poorer than the 6- to 7-year-old children with TLD on the Birthday Story and ERRNI inference questions, which required the integration of information that was not explicitly presented, the two groups of children performed comparably on all literal questions (Dodwell & Bavin, 2008), which is inconsistent with the work previously discussed (e.g., Crais & Chapman, 1987; Norbury & Bishop, 2002). Furthermore, the children with SLI were significantly poorer than their peers in recalling the Birthday Story, the story they had heard. Listening to and remembering a story for later recall relies on attention and the integration of new information with that from long-term memory. In contrast, when generating and recalling the ERRNI Fish Story the children with SLI provided a comparable amount of information as their peers. This study demonstrated that the children were better at remembering the stories they told; telling their own story in the ERRNI facilitated a stronger representation upon which the children could draw on when retelling the story. Dodwell and Bavin (2008) also found that the measure of the episodic buffer (recalling sentences) was significantly correlated with the recall and comprehension of both stories, and performance on a measure of the phonological loop (word list recall) was significantly correlated with the recall and comprehension of the ERRNI story.

Generation, Recall, and Understanding of Narratives in Resolved Late Talkers

Limited research has investigated whether children with a history of late talking but whose language scores are in the normal range demonstrate impaired narrative skills during their preschool to early school years. Paul, Hernandez, Taylor, and Johnson (1996) reported a study examining narrative skills in late talkers. Based on parent responses on the LDS (Rescorla, 1989), Paul and her colleagues recruited 26 late-talking children who produced fewer than 50 words at 20-34 months of age and a group of 30 children who used more than 50 words at 20-34 months. The language abilities of these children were assessed during kindergarten, grade one, and grade two, and at each of these assessments the children were assigned to one of three groups based on their expressive language skills: “normal” language group, history of expressive language delay group (HELD; children who were identified as late talkers at 2 years and performed within the normal range at school age), and expressive language disorder group (ELD; children who were identified at age 2 years as late talkers and continued to show deficits in expressive syntax and morphology at school age). By kindergarten and grade one (mean age of 5;10 and 6;10, respectively), approximately 63% and 73% of the late talkers, respectively, were in the HELD group. At each of these assessments, children also completed a narrative task, in which they either generated a story from a picture book or recalled a narrative told by the examiner. During kindergarten and first grade, the children in the HELD group generated the same amount of information from a picture book as children with normal language and children who continued to meet criteria for an expressive language disorder (ELD group; Paul et al., 1996). However, despite their normal expressive language skills, the children in the HELD group did score significantly lower than the typically developing children in the breadth of their vocabulary (lexical diversity) and narrative plot structure. The ELD and HELD groups did not differ from each other on any narrative measure. By age 8;0 years (second grade), 86% of the late talkers were in the HELD group and there were no differences among any of the groups on narrative performance. Paul et al. suggested that deficits in narrative skills tend to disappear with increasing age in children with a history of early language delay.

In a longitudinal study, Manhardt and Rescorla (2002) utilised the wordless picture book, *Frog, Where are You?* (Mayer, 1969) to investigate three aspects of narrative skills, global plot structure, linguistic complexity, and evaluative devices, in a group of children with a history of early language delay and a group of 23 typically developing children. At age 24 to 31 months, 31 children were identified as late talkers; they scored at least six months below their chronological age on the Reynell Expressive Language Scale (Reynell, 1977) and had fewer than 50 words or no word combinations on the Rescorla's LDS (1989). All late talkers scored at least 85 on the measure of nonverbal ability, the Bayley Scales of Infant Development (Bayley, 1969). At 24 to 31 months, the typically developing children were matched to the late talkers on chronological age, socioeconomic status, and nonverbal cognitive ability. At ages 8 and 9 years, the late talkers and typically developing children were asked to generate oral narratives. At age 9 years, each child was also asked to tell the story a second time in a "supported telling condition", in which children were introduced to three types of evaluative devices: characters' emotions, characters' speech, and causal connectors. If the child did not spontaneously mention the evaluative information targeted on the particular page, the examiner prompted him/her (e.g., "I wonder what the boy is saying to those frogs").

Manhardt and Rescorla (2002) found that the late talkers scored significantly poorer than the children with TLD on narrative factor scores in syntax (i.e., complex syntax structures), inclusion of story components (e.g., initiating event, goal-directed action, and consequence), and evaluative devices across all three tellings of the narratives. It was also found that both groups of children benefitted equally from the prompts provided in the supported telling condition; all children used significantly more evaluative devices. Of note, the late talkers scored in the average range at age 8 years on the Clinical Evaluation of Language Fundamentals – Revised (CELF-R; Semel, Wiig, Secord, & Sabers, 1987), but as a group their scores were significantly lower than those of the typically developing group. When group differences on the global plot structure factor were reanalysed controlling for CELF-R scores, the late talkers continued to exhibit a weakness in their story structure. This suggests that the organisation of a narrative structure, which requires events to be prioritised, integrated, and understood, may be a specific area of difficulty for RLTs. As there was no measure of nonverbal cognitive ability at ages 8 or 9 years, it is unknown as to whether the groups also significantly differed on nonverbal ability.

Summary

It is clear from the research discussed that children with SLI have difficulties constructing and understanding oral narratives. However, what is not clear is whether they experience difficulties in all aspects of narrative production. For example, although narrative recall may be similar to that of typically developing children, differences emerge when questions requiring inferencing are asked. Furthermore, the varying nature of the narrative tools used, the age range of children tested and the variability in language skills within the SLI groups (expressive vs. receptive) have led to differing results being reported in the SLI literature. In relation to RLTs, there is limited research investigating narrative skills and the results of the research that has been conducted are inconsistent. For example, Paul et al. (1996) found that late talkers who had normal expressive language skills in second grade did not have impaired narrative skills. However, Manhardt and Rescorla (2002) assessed slightly older RLTs, who were in grades three and four, and found these children to be significantly lower on global plot structure scores than typically developing children. Two studies were designed to investigate some of these issues further; details are reported in Chapters 6 and 7.

CHAPTER 5

STUDY ONE

Introduction

Methodological differences may explain some of the different findings regarding working memory deficits in SLI as discussed in Chapter 3. Firstly, many studies have included small samples of children with SLI recruited from clinical samples, such as language units and special schools. There is a need for larger population-based studies to determine the extent to which findings can be generalized. Secondly, the age range of children with SLI in many of the research studies is large. Undoubtedly studies recruit from a wide age range in order to identify a sample large enough for group comparisons, but memory develops throughout childhood and early adolescence. Some of the differences in findings across studies may be due to the within-group variability resulting from the wide age ranges tested. Other differences in research findings may be due to the variability resulting from the different criteria used for classifying SLI and late-talking status and the different measures used. There is much variability across studies in the criteria used for classifying SLI, with studies using cut-offs ranging from 1 to 2 standard deviations below the mean on standardized language assessments and cut-offs varying from a standard score of 70 to 85 on nonverbal cognitive assessments. In relation to late talkers, children who had received regular speech-language therapy have been classified as late talkers, while other studies have used standardised parent report measures of language. Lastly, previous studies examining the contribution of working memory on language impairment have not focused on all four components of Baddeley's model of working memory in the same group of children. Research can address many of these issues by testing a large sample of children using multiple assessments of each component.

Aim and Hypotheses

The aim of Study One was to examine the working memory abilities of children with SLI, RLTs and children with TLD who are participating in the ELVS, a longitudinal population-based study (for further information about the study see Bavin et al., 2008; Reilly et al., 2006; Reilly et al., 2008; Reilly et al., 2007; Reilly et al., 2010). The study assessed each component of Baddeley's model of working memory. The main research questions were:

1. Are RLT's significantly different from children with SLI on memory tasks testing the four components of the Baddeley model of working memory?
2. Can we identify different profiles for children who were late talkers and resolved and late talkers who continue to have language problems and are identified with SLI?

Based on previous research, as discussed in Chapter 3, seven hypotheses were formulated:

i. The first hypothesis predicted that the children with SLI would have significantly lower scores than the children with TLD on two measures of phonological memory, digit and word list recall, and that the RLT group would perform significantly better than the SLI group, but not as well as the TLD group.

ii. Secondly, it was hypothesised that the children with SLI would perform significantly poorer than the children with TLD on a nonword repetition task. Additionally, if there are residual effects of late-talking status, the RLTs would perform significantly better than the children with SLI but not as well as the children with TLD.

iii. Based on the findings from Bavin et al. (2005), Hick et al. (2005a), and Nickisch and von Kries (2009), hypothesis three predicted that the performance of the children with SLI would be poorer than the TLD group on two visuo-spatial tasks included to test the visuo-spatial sketchpad component of Baddeley's working memory model

(Baddeley, 2000; Baddeley & Hitch, 1974): block recall and picture location. No prediction was made for the RLTs.

iv. Hypothesis four predicted that children with SLI would have significantly lower scores than the TLD group on the measure of the episodic buffer: recalling sentences. Additionally, if there are residual effects of late-talking status, it was predicted that the RLT's would perform significantly better than the SLI group, but not as well as the TLD group on this task.

v. The fifth hypothesis was that children with SLI would perform significantly poorer than the TLD group on the verbal central executive task, backward digit recall, and that the RLT group would perform significantly better than the SLI group but not as well as the TLD group.

vi. Based on the findings of Hoffman and Gillam (2004), the sixth hypothesis predicted a significant difference between the SLI and TLD groups on the three verbal conditions and the three spatial conditions of a dual processing task.

vii. Based on empirical and theoretical links, the seventh hypothesis predicted significant correlations amongst the variables measuring each component of working memory.

Method

Participants

Participants were recruited from ELVS, a prospective, cohort study of language development. The ELVS commenced in 2002, at which time 1,910 infants aged 7.5 to 10 months were recruited through Maternal and Child Health Clinics in six of the 31 metropolitan Melbourne local government areas (LGAs) in the state of Victoria. The clinics provide regular check-ups for children 0 to 6 years of age. Two LGAs from each of the three tiers of socio-economic areas, as determined by the Australians census-based Socio-Economic Indexes for Areas (SEIFA) Index for Relative Socioeconomic Disadvantage, were selected to ensure sampling across the spectrum of disadvantage-to-advantage and geographic spread (For further details of ELVS see Bavin, et al., 2008; Reilly, et al., 2006; Reilly, et al., 2007; Reilly, et al., 2010). To measure vocabulary at the age of 2 years, the CDI Words and Sentences (Fenson et al., 1993) was included in a questionnaire package to be completed by parents. With permission from the authors and publishers, modifications were made to accommodate differences between American and Australian English usage; 24 vocabulary items were substituted (e.g., *couch* for *sofa*). The CDI was selected as it is commonly used and has been used by the ELVS to identify late talkers or children at the low end of the expressive vocabulary distribution (D'Odorico, Assanelli, Franco, & Jacob, 2007; Stokes & Klee, 2009). Children were identified as late talkers if the number of words produced was at or below the 10th percentile using the CDI norms. At age 4 years, the children were assessed with the Clinical Evaluation of Language Fundamentals–Preschool, Second Edition (CELF-P2; Wiig, Secord, & Semel, 2006) to identify SLI status[1]. Based on the work of Tomblin, Records, and Zhang (1996), the cut-off score for inclusion in the SLI group was at least 1.25 standard deviations below the mean on the expressive or receptive language scales. In addition, the Matrices task of the Kaufman Brief Intelligence Test (K-Bit; Kaufman & Kaufman, 2004) was used as a measure of nonverbal cognitive ability. The Matrices subtest (Mean = 100; SD = 15) assesses the ability to solve new problems through perceiving relationships and completing analogies.

For the current study, one hundred and two 5-year-old children aged 60 to 68 months (*M* age = 63.03, *SD* = 1.76) were recruited and assessed from the ELVS sample. As part of

[1] A language assessment, Clinical Evaluation of Language Fundamentals – Fourth Edition (CELF-4; Semel, Wiig, & Secord, 2003), was conducted when the children turned 5 years of age. However, scores were not available at the time of recruitment for the current study, and therefore, the 4-year-old data was used to identify the participants for this research.

the ELVS project, children were assessed at age 5 years. At that session, parent information statements about the current study and informed consent forms (See Appendix A) were given to parents of all children identified as SLI at age 4 years and those identified as RLTs, in addition, to a stratified sample (across Socio Economic Status [SES] areas) of typically developing children identified by the manager of the ELVS project. Late talkers from non-English speaking and bilingual backgrounds were excluded in the recruitment because having a second language in the first two years is a possible confound in determining vocabulary level using the CDI (Fenson, et al., 1993). Children who participated in other sub-studies of ELVS were excluded in the recruitment process so as not to overtax the families. At the time of recruitment, no child was identified as having a hearing, neurological or social impairment, or a known developmental delay (other than language). Appendix B is a flow chart showing the number of children, by language group and gender, participating in the current study; those who met criteria for inclusion in the SLI, RLT and TLD groups at age 4 years and who were invited because they were not included in other sub-studies.

Using the recruited sample of RLTs, a one-way analysis of variance (ANOVA) revealed a main effect of group when comparing the K-Bit Matrices standard scores across the three groups: $F(2, 97) = 5.97$, $p = .004$, $\eta_p^2 = .11$. The RLT group had significantly higher K-Bit standard scores than both the SLI and TLD groups. To control for the influence of nonverbal cognitive ability on any group differences on the working memory measures, the children in the RLT group with the two highest standard scores (127 and 124) were excluded from analyses ($n = 5$). The subsequent comparison found no significant group differences on K-Bit standard scores at the .05 alpha level. Post-hoc comparisons using the Tukey Honestly Significant Difference (HSD) test indicated that the RLTs had comparable nonverbal cognitive abilities relative to the SLI group ($p = .16$) and the TLD group ($p = .07$). However, it should be noted that the RLT group did have a higher mean score as well as a higher maximum score on the measure of nonverbal ability than the other two groups (See Table 2). Two additional children were assessed, but were subsequently excluded from analyses as one child in the SLI group was later diagnosed with an Autism Spectrum Disorder and a developmental delay was confirmed for one child in the RLT group.

Data are reported for the final sample of 95 children. There were three groups: 24 children with SLI (*M* age = 63.29 months, *SD* = 1.99; Males = 10, Females = 14), 39 RLTs (*M* age = 62.87, *SD* = 1.64; Males = 13, Females = 26), and 32 children with TLD (*M* age = 63.19, *SD* = 1.75; Males = 13, Females = 19). A summary of the characteristics of each group is presented in Table 1. A one-way ANOVA confirmed that there was no significant group difference in age, $F(2, 92) = 0.50$, $p = .61$, $\eta_p^2 = .01$. The uneven distribution of males and females in the groups, particularly in the RLT group, reflects the disproportionate number of females whose parents consented to their participation in the study.

Table 1

Characteristics of the Three Groups of Children (SLI, RLT, TLD)

	Group		
	SLI (n = 24)	RLT (n = 39)	TLD (n = 32)
Chronological Age (months)			
M	63.29	62.87	63.19
SD	1.99	1.64	1.75
Sex			
Male	10	13	13
Female	14	26	19
LGA (SES)			
Low	8	11	10
Medium	3	11	7
High	13	17	15

The children in the SLI group had a history of late talking at age 2 years and were identified as SLI at 4 years of age. Based on the composite scores from the Expressive and Receptive subtests of the CELF-P2 (Wiig, et al., 2006), nine children from the SLI group were classified as Expressive-SLI (standard score of 81 or below on the Expressive scale, with standard score above 81 on the Receptive scale), seven as Receptive-SLI (standard score of 81 or below on the Receptive scale, with standard score above 81 on the Expressive scale), and the remaining eight children were classified as mixed Expressive-Receptive SLI (standard scores at or below 81 on both the Expressive and Receptive scales). The Expressive composite scores for children in the Receptive-SLI group were 87 or greater. The

RLTs were all identified as late talkers at age 2 years and not SLI at age 4 years. The children in the TLD group were not late talkers at age 2 years and not identified as SLI at age 4 years. At age 4 years, children in all three groups achieved a standard score of 85 or greater on the Matrices task from the K-Bit (Kaufman & Kaufman, 2004). Standard scores for the screening measures at age 2 and 4 years for each group appear in Table 2.

Table 2

Comparison of Groups (SLI, RLT, and TLD) on Screening Measures: Vocabulary Production, Nonverbal IQ, and CELF-P2 Expressive and Receptive Language Scores

	SLI		RLT		TLD	
	M	*(SD)*	*M*	*(SD)*	*M*	*(SD)*
	[Min – Max]		[Min – Max]		[Min – Max]	
CDI: Vocabulary[1]	55.96	(37.51)	57.87	(38.49)	321.16	(120.72)
	[1 – 116]		[0 – 187]		[139 – 503]	
K-Bit[2]	102.29	(10.45)	106.85	(9.90)	101.75	(7.96)
	[85 – 118]		[86 – 121]		[90 – 118]	
CELF Expressive composite[2]	80.36	(7.31)	100.00	(9.89)	105.19	(10.52)
	[70 – 100]		[85 – 124]		[91 – 126]	
CELF Receptive composite[2]	79.04	(7.20)	100.36	(9.26)	103.37	(8.50)
	[64 – 92]		[86 – 115]		[88 – 118]	

[1] Two-year-old screening measure. [2] Four-year-old screening measure.

Consistent with the selection criteria, there was a significant main effect of group on all language measures at ages 2 and 4 years. The TLD group had a significantly larger vocabulary than both the SLI ($p < .001$) and RLT ($p < .001$) groups at age 2 years, whereas the SLI and RLT groups achieved a comparable vocabulary score (*p* = .99). At age 4 years, the RLT and TLD groups achieved significantly higher standard scores on both the Receptive and Expressive composite scales of the CELF-P2 than the SLI group (all group differences, *p* < .001). In addition, the RLT group achieved lower mean scores on the Expressive and Receptive composite scales than the TLD group, although these group differences were not statistically significant (Receptive *p* = .30, Expressive *p* = .06).

Materials

Working memory measures.

Phonological loop. Three tasks were included to measure the phonological loop: Digit Recall and Word List Recall from the WMTB-C (Pickering & Gathercole, 2001) and the CNRep (Gathercole & Baddeley, 1996).

Digit span: For Digit Recall, the examiner states aloud a sequence of digits and asks the child to recall each sequence immediately after in the same order. Following three practice lists, a maximum of six lists are presented at each length of digits. List length increases by one if the child recalls four lists at that length correctly and continues to a maximum of nine digits. If the first four trials at each length are correct, the child is credited with correct recall of all six lists at that length and the next list length commences. Testing commences with one digit and ceases when the child incorrectly recalls three lists at a given length. Children's responses were recorded on-line. The number of correct trials was counted, and standardized scores calculated. The test-retest reliability coefficient for children aged between 5 and 8 years is .81.

Word span: In Word List Recall, word lists range from one to seven monosyllabic words with a consonant-vowel-consonant structure. Three practice items precede the test trials. Six lists are given at each length, and correct repetition of four out of six lists at a given length results in progression to the next list length. The word span is the maximum length at which the child is able to correctly repeat at least four lists of words. Children's responses were recorded on-line. The number of correct trials was counted, and standardized scores calculated. Test-retest reliability coefficient for children aged between 5 and 8 years is .80.

The Children's Test of Nonword Repetition: The CNRep (Gathercole & Baddeley, 1996) was the third task. It is argued to be a test of the phonological loop, but also taps other cognitive processes including speech perception, phonological representations, lexical knowledge, and speech motor output processes (e.g., Archibald & Gathercole, 2006c; Bishop, North & Donlan, 1996). The CNRep is a standardized test, which consists of 40 nonwords varying in length from two to five syllables. Short nonwords are two to three syllables and long nonwords are four to five syllables. Children are required to repeat a nonword immediately after it has been presented. With the permission of the authors, an Australian female voice announcing each nonword was pre-recorded. The responses were audio recorded for later scoring. The test-retest reliability coefficient is .77.

Visuospatial sketchpad. Two tasks were included to measure the visuospatial sketchpad: the block recall task from the WMTB-C (Pickering & Gathercole, 2001) and the picture locations task from the Children's Memory Scale (CMS; M. J. Cohen, 1997).

Block recall: In the block recall subtest, the examiner taps a sequence of cubes on a board that has nine randomly located cubes. The child's task is to repeat the sequence. Three practice items precede the test trials. Testing begins with a single block tap, and is increased by one additional block following each list length (a set of six trials). Testing ceases when the child incorrectly taps three sequences of blocks at a given length. The number of correct trials is counted, and standardized scores calculated. Test-retest reliability on the test for children aged between 5 and 8 years is .63.

Picture Locations: The picture locations task measures visual memory for spatial locations of pictured objects. The child views pictures placed in various locations within a 3 x 4 grid. The pictures are removed from view and the child is asked to place response chips on the grid in the same locations as the pictures previously viewed. Testing commences with one picture and increases to five pictures, with two presentations at each length. The number of correctly placed chips is calculated and converted to standardized scores. The reliability co-efficient for children aged 5 years is .76.

Episodic buffer. *Clinical Evaluation of Language Fundamentals – Fourth Edition (CELF-4). Recalling Sentences.* Based on the work by Alloway and colleagues (2004), the recalling sentences subtest from the CELF-4 (Semel, et al., 2003) served as the measure of the episodic buffer. Recalling sentences involves the integration of information from the phonological loop with semantic and syntactic information from the language processing system. The child is asked to accurately repeat sentences of increasing length and complexity spoken by the examiner until five consecutive zero scores are recorded. The sentences are scored as correct if all of the words are repeated in the correct order. The maximum possible score for each sentence is three and points are deducted depending on the number of words changed, added, substituted, omitted, or reversed.

Central executive. *Backward Digit Recall*: The backward digit recall test of the WMTB-C (Pickering & Gathercole, 2001) was used as a measure of the central executive. As in digit recall, digit sequences are presented and the child is asked to recall the sequence of spoken digits in reverse order. The lists range from two to seven digits, with six lists at each length. Practice trials are given in order to ensure that the child understands the concept of reversal. Correct reversal of four lists at a given length results in progression to the next list length. The task is discontinued when the child makes three errors at a given length. The number of correct trials is counted, and standardized scores are calculated. Test-retest reliability for children aged between 5 and 8 years is .53.

Dual processing task.

The dual processing task was a modified version of the one used by Hoffman and Gillam (2004). As in Hoffman and Gillam's study the task consists of two domain conditions (verbal and spatial) that are paired with one of three colour identification conditions (none, naming, pointing). See Figure 2 for a diagram of the task conditions. In the verbal domain conditions, digits were presented on a computer screen and children were instructed to repeat the sequence of digits after they appeared on the screen. In the spatial domain conditions, X's were presented in various positions on a 3 x 3 grid and children were asked point to the sequence of locations on the grid where X's had appeared on the computer screen. X's appear one at a time in individual cells of the grid. In the colour naming condition, children were asked to name the colour of each stimulus (digit or X) immediately after presentation and then recall the digits or locations of the X's once all stimuli had been presented. Similarly, in the colour pointing condition, children were asked to point to the colour of each stimuli (digit or X) from a row of colours at the bottom of the computer screen immediately after each stimulus disappeared, before recalling all digits or locations of the X's. A condition with no colour identification (pointing or naming) provided the base measure.

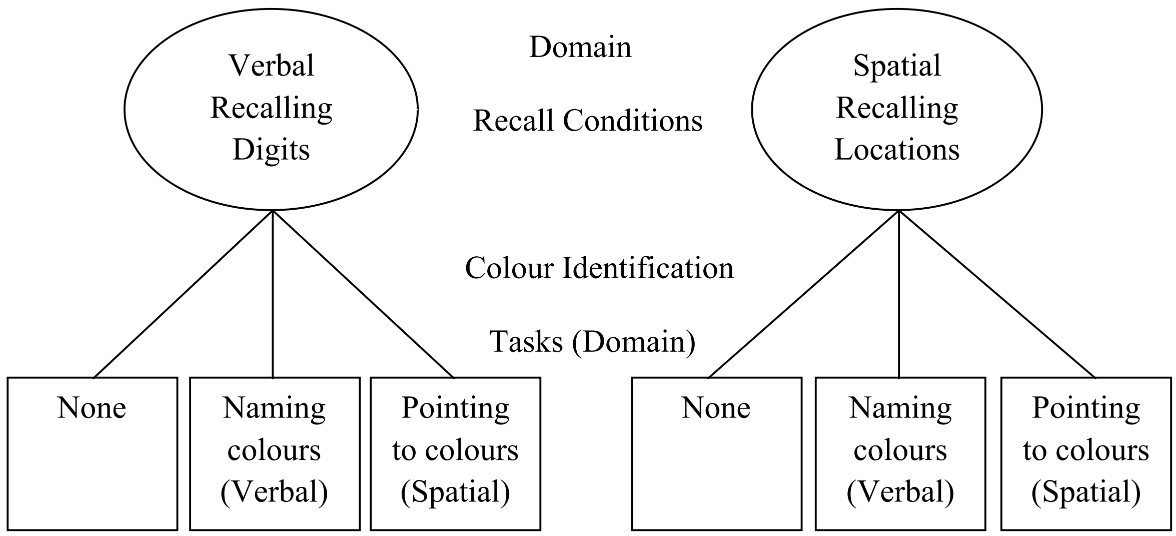

Figure 2. Schematic of the six conditions of the dual processing task adapted from Hoffman and Gillam (2004).

The stimuli were developed to be similar to those used by Hoffman and Gillam (2004), with three colours of digits and X's (red, blue, and green). No colour occurred more than twice in succession within a single list, with each colour occurring with equal frequency across the conditions. In the verbal domain conditions, the digits were displayed one at a time on the computer screen. In the spatial domain conditions, X's appeared one at a time in individual cells of a 3 x 3 grid. The presentation rate was set at 2.25s with a 2.25s inter-stimulus interval.

Prior to administering the task, the children's ability to read digits one through nine and to identify the three colours was tested. The verbal domain conditions were not administered to children who were unable to read the digits one through nine: six children with SLI, two RLTs, and six children with TLD. All children were able to name the three colours. Two practice trials were included for each of the six conditions and within each condition three lists at each list length were presented. The practice trials were repeated until the children could respond correctly to both. Testing in each condition commenced with a span of two items and the list length increased by one item up to a maximum span of seven items. Testing within each condition ceased if the child failed to correctly recall at least two lists at any given length. Spans for each condition were defined as the maximum list length at which the child repeated two lists correctly. The order of the verbal and spatial domain conditions was counterbalanced to control for order effects. Approximately half of the children within each group completed the verbal domain conditions before the spatial domain conditions (SLI: 13, RLT: 20, TLD: 14) and the remaining children performed the spatial domain conditions before the verbal domain conditions (SLI: 11, RLT: 19, TLD: 18). Inspection of the Standard Residual values (using a critical value of $z \pm 1.96$) revealed that there were no significant differences within groups on whether the verbal or spatial domain conditions were presented first. A Chi-square test for independence on the order of presentation indicated no significant difference in order of recall conditions between groups, χ^2 (2, n = 95) = .68, p = .71.

Procedure

Ethics approval to undertake the study was obtained from the La Trobe University Human Ethics Committee and the Royal Children's Hospital Human Research Ethics Committee (See Appendix C for ethics approval certificates). Following the 5-year-old ELVS assessment, parents who indicated that they agreed to have their child participate on the returned informed consent form were contacted and an appointment was made. The author tested all children individually in one session, which lasted approximately 50 minutes. All testing was conducted in a quiet area of the children's home or the Language Research Unit at La Trobe University, depending on parents' preference. Parents who indicated on the returned consent form that they did not wish to have their child participate were not contacted.

The experimental tasks were administered in the same order for each child: Digit Recall, Word List Recall, Block Recall, Backward Digit Recall, Picture Locations, and the Dual Processing Task. All of the tasks from the WMTB-C (Pickering & Gathercole, 2001) were administered in accordance to the order specified in the standardized process protocol; this was followed by Picture Locations as it came from a different test battery. Given the complexity of the dual processing task, this task was administered last. Responses were recorded on-line and the verbal tasks were tape-recorded for checking. The CNRep and Recalling Sentences task was administered during the ELVS 5-year-old session and the raw and standard scores were made available to the author. The examiner was blind to the language status of the children during the time of the assessment and scoring.

Results

Data was screened for accuracy of entry, missing values, and violations of the statistical assumptions prior to statistical analysis using PASW Statistics 18. No adjustments were needed for the missing values in Word List Recall or the conditions in the spatial domain of the dual-processing task because there was less than 5% of values missing, and while there was 6.3% of values missing for the CNRep, a t-test showed no systematic relationship between the missing values and language group ($p = .24$). For the dual-processing task verbal domain baseline and colour naming conditions 13.7% of data were missing; in the verbal domain colour pointing condition 14.7% of values were missing. T-tests showed no systematic relationships between group and each of the verbal domain conditions (baseline, $p = .51$; naming condition, $p = .51$; pointing condition, $p = .72$). Given that the pattern of missing values appeared to be a random subsample of the whole sample, the cases with missing values were dropped in the relevant analyses (Tabachnick & Fidell, 2007).

The frequency distribution of each variable was assessed for violations of the assumption of normality using standardized indices (z) of skewness and kurtosis with a conservative criterion of $\alpha = .001$ (see Tabachnick & Fidell, 2007). The spatial domain, colour pointing condition on the dual-processing task was positively skewed for the SLI group only. Twenty-one (87.5%) children with SLI were at floor level, scoring zero. To allow for the comparison of this condition with the other dual-processing conditions, this variable was not transformed. No other variable was found to violate the assumption of normality. Outliers were identified in the following variables: Digit Recall, CNRep, Recalling Sentences, Picture Locations, and Backward Digit Recall. To reduce the impact of these outliers, the outlying scores were moved to the next highest (or lowest) possible score plus (or minus) one, depending on whether it was an upper or lower bound outlier (Tabachnick & Fidell, 2007, p. 77). See Appendix D for the number of upper and lower bound outliers in each group on the measures of working memory.

A combination of ANOVA and multivariate analysis of variance (MANOVA) was used to explore group differences on the measures of working memory. When the null hypothesis was rejected, pairwise comparisons using post hoc Tukey HSD tests were performed. Mixed-model repeated measures ANOVAs were also used to investigate group differences on various tasks (e.g., dual processing task), and when significant effects were found, univariate ANOVA were evaluated using a Bonferroni adjusted error rate to control for the inflation of Type I errors. Effect sizes are reported for main effects using partial eta squared (η_p^2). For η_p^2, .01 is considered a small effect size, .09 a medium effect, and .25 a large effect size (J. Cohen, 1988). For the Pearson product-moment correlation the equivalent effect sizes are .10 to .29, .30 to .49, and .50 to 1.0, respectively (J. Cohen, 1988, pp. 79-81). Descriptive statistics for the working memory measures for each group are provided in Table 3.

Table 3

Mean Standard Scores, Standard Deviations, and Range of Scores for each of the Working Memory Measures

	SLI		RLT		TLD	
	M	*(SD)*	*M*	*(SD)*	*M*	*(SD)*
Measure	[Min – Max]		[Min – Max]		[Min – Max]	
Phonological Loop						
Digit Recall	86.87	(7.18)	96.56	(12.94)	101.50	(9.71)
	[75 – 101]		[69 – 125]		[83 – 122]	
Word List Recall	90.46	(11.11)	97.28	(18.09)	99.39	(16.22)
	[70 – 113]		[59 – 129]		[65 – 124]	
CNRep	89.05	(15.90)	97.78	(14.72)	104.13	(17.86)
	[68 – 115]		[71 – 130]		[78 – 137]	
Visuospatial Sketchpad						
Block Recall	86.46	(17.99)	97.85	(16.62)	90.56	(16.59)
	[57 – 112]		[63 – 125]		[60 – 115]	
Pictures Location	9.12	(2.88)	10.15	(2.59)	9.37	(2.48)
	[4 – 15]		[5 – 15]		[4 – 15]	
Executive Functioning						
Backward Digit Recall	82.46	(10.05)	86.33	(12.89)	89.72	(10.20)
	[66 – 96]		[66 – 112]		[70 – 107]	
Episodic Buffer						
Recalling Sentences	6.08	(2.57)	9.33	(2.32)	10.47	(1.92)
	[2 – 12]		[4-14]		[6-14]	

Phonological Loop

To examine hypothesis one, that the SLI group would perform significantly poorer than the TLD group on the phonological memory tasks, and that the RLT group would perform significantly better than the SLI group, but not as well as the TLD group on these tasks, a 2 (Phonological measure: Digit Recall and Word List Recall) x 3 (Group: SLI, RLT, TLD) MANOVA was performed. A main effect for group was found, $F(4, 182) = 6.03$, $p < .001$; $\eta_p^2 = .12$, with a medium effect size. When the results for the dependent variables were considered separately, the only significant group difference was on digit recall, $F(2, 91) = 13.03$, $p < .001$, $\eta_p^2 = .22$ (Word List Recall: $F(2, 91) = 2.26$, $p = .11$, $\eta_p^2 = .05$). Post hoc Tukey HSD tests indicated that children with SLI scored significantly lower than both the RLT group ($p = .002$) and the TLD group ($p < .001$), whereas the RLT and TLD groups performed comparably ($p = .13$).

On the digit recall task, 6.3% of children with TLD and 12.8% of the RLTs scored 1 standard deviation (i.e., < 86) below the mean, as compared to 29.2% of children with SLI. On the word list recall task, 16.1% of children with TLD and 17.9% of RLTs scored 1 standard deviation below the mean, as compared to 29.2% of children with SLI. Separate chi-square tests of independence indicated that relative to children with TLD, a greater number of children with SLI scored 1 standard deviation below the mean on the digit recall task ($p = .03$, one-sided Fisher's exact test), but not on word list recall (χ^2 (1, $n = 55$) = 1.35, $p = .25$). A similar number of RLTs and children with SLI scored more than 1 standard deviation below the mean on digit recall ($p = .18$, two-sided Fisher's exact test) and word list recall (χ^2 (1, $n = 63$) = 1.08, $p = .30$).

A univariate ANOVA was used to assess group differences on the CNRep[2]. The results indicated a significant group difference: $F(2, 86) = 5.46$, $p = .006$, $\eta_p^2 = .11$. Tukey HSD post hoc comparisons indicated that children with SLI accurately repeated significantly fewer nonwords than the TLD group ($p = .004$). The mean performance of the RLTs (M = 97.78) was between that of the children with SLI (M = 89.05) and children with TLD (M = 104.13); however, no further significant group differences were found.

To determine if word length significantly affected performance across groups, correct scores for short (two to three syllable) and long (four to five syllable) nonwords were compared. The mean raw scores, standard deviations, and range of scores for the three groups at each length (maximum score of twenty) are displayed in Table 4.

Table 4

Comparison of 5-year-old Children with SLI, RLTs, and Children with TLD on the Number of Short and Long Nonwords Correctly Repeated on the CNRep

	SLI		RLT		TLD	
	M	*(SD)*	*M*	*(SD)*	*M*	*(SD)*
Syllable Length	[Min – Max]		[Min – Max]		[Min – Max]	
Short	13.05	(3.37)	14.11	(2.82)	14.90	(2.98)
	[8 – 19]		[7 – 19]		[7 – 20]	
Long	4.33	(3.44)	6.43	(4.05)	8.13	(4.62)
	[1 – 11]		[1 – 14]		[2 – 17]	

[2] The CNRep was analysed separate to the other two measures of the phonological loop as it did not come from the same test battery. In addition, the CNRep did not correlate significantly with word list recall for any group, and nor with digit recall for the SLI group.

The results of a 3 (Language Group: SLI, RLT, TLD) x 2 (Syllable Length: Short and Long) mixed-model repeated measures ANOVA revealed no significant interaction, $F(2, 86) = 2.09$, $p = .13$, $\eta_p^2 = .05$. However, there was a significant main effect for group, $F(2, 86) = 4.89$, $p = .01$, $\eta_p^2 = .10$, with a medium effect size, and a significant main effect of syllable length with a large effect size, $F(1, 86) = 453.86$, $p < .001$, $\eta_p^2 = .84$. All groups accurately repeated more short nonwords than long nonwords. Univariate ANOVAs revealed significant group differences on the long nonwords, $F(2, 86) = 5.30$, $p = .007$, $\eta_p^2 = .11$, but not on the short nonwords, $F(2, 86) = 2.38$, $p = .10$, $\eta_p^2 = .05$. For the long nonwords, post hoc comparison using the Tukey HSD test showed that the SLI group accurately repeated significantly fewer nonwords than the TLD group ($p = .005$). However, there was no significant difference between the SLI and RLT groups ($p = .16$), or the TLD and RLT groups ($p = .22$).

Visuospatial Sketchpad

As the measures of the visuospatial sketchpad were taken from two different standardised test batteries, two separate one-way ANOVAs were conducted. For block recall, the one-way ANOVA yielded a significant overall effect of group: $F(2, 92) = 3.67$, $p = .03$, $\eta_p^2 = .07$. Post hoc comparisons using the Tukey HSD test revealed that the RLT group outperformed children with SLI ($p = .03$), whereas the SLI and TLD groups performed comparably ($p = .64$). No difference was found between the RLT and the TLD groups ($p = .17$). For picture locations, the one-way ANOVA revealed no significant between-group differences: $F(2, 92) = 1.36$, $p = .26$, $\eta_p^2 = .03$.

Episodic Buffer

To examine the hypothesis that significant differences would be found between the three groups on the measure of the episodic buffer (recalling sentences task), a one-way ANOVA was performed, with group as the between-subjects factor. As predicted, a significant large effect of group was found: $F(2, 92) = 27.03$, $p < .001$, $\eta_p^2 = .37$. Post hoc comparisons using the Tukey HSD test indicated that performance of both the RLT ($p < .001$) and TLD ($p < .001$) groups was significantly higher than that of the SLI group, whereas no difference was found between the RLT and TLD groups ($p = .09$).

Central Executive

In order to test hypothesis five, that children with SLI would perform significantly poorer than children with TLD on the measure of the central executive, and that the RLT group would perform significantly better than the SLI group, but not as well as the TLD group, performance on the backward digit recall task was analysed using a one-way ANOVA. Although the mean standard score for the SLI group was lower than that of the RLT and TLD groups, the between-group difference was not significant at the .05 alpha level: F (2, 92) = 2.81, $p = .06$, $\eta_p^2 = .06$. On the backward digits recall task, 41.7% of the children with SLI scored at least 1 standard deviation below the mean, as compared to 35.9% of the RLTs and 25% of children with TLD. Two Chi-square tests for independence indicated that, relative to children with SLI, a similar number of children with TLD (χ^2 (1, n = 56) = 1.75, $p = .19$) and RLTs (χ^2 (1, n = 63) = 0.21, $p = .65$) scored more than 1 standard deviation below the mean on this task. From observation, it appeared that some of the children from each group did not know their numbers. All three groups of children found this task difficult, suggesting that the task is not a good discriminatory tool for this age.

Further Analyses

The groups did not differ significantly on nonverbal IQ as measured by the K-Bit Matrices subtest. However, given that nonverbal IQ could contribute to individual performances, analyses using an ANCOVA or MANCOVA were conducted to determine if the results reported above held if K-Bit standard scores were included as a covariate in the analyses (See Table 5 for adjusted means and standard error). The results showed that for the measures of the phonological loop, episodic buffer and central executive, adjusting for nonverbal cognitive ability did not alter the results. There continued to be significant group differences, with no change to the effect size, on digit recall [$F(2, 90) = 12.93$, $p < .001$, $\eta_p^2 = .22$], CNRep [$F(2, 85) = 5.30$, $p = .007$, $\eta_p^2 = .11$], and recalling sentences [$F(2, 91) = 26.73$, $p < .001$, $\eta_p^2 = .37$] and no significant group differences on word list recall [$F(2, 90) = 2.19$, $p = .12$, $\eta_p^2 = .05$] and backward digit recall [$F(2, 91) = 2.82$, $p = .06$, $\eta_p^2 = .06$]. After adjusting for nonverbal IQ, there were no longer significant between-group differences on either measure of the visuospatial sketchpad: block recall, $F(2, 91) = 2.88$, $p = .06$, $\eta_p^2 = .06$; picture locations, $F(2, 91) = 1.06$, $p = .35$, $\eta_p^2 = .02$. That is, the between-group difference found originally on the visuospatial sketchpad task, block recall, can be attributed to individual children's performance on the K-Bit Matrices task.

Table 5

Adjusted Mean Standard Scores and Standard Error for each of the Working Memory Measures

	SLI		RLT		TLD	
Measure	*M*	*(SE)*	*M*	*(SE)*	*M*	*(SE)*
Phonological Loop						
Digit Recall	87.01	(2.20)	96.34	(1.75)	101.82	(1.95)
Word List Recall	90.74	(3.27)	96.82	(2.60)	99.75	(2.89)
CNRep	89.01	(3.55)	97.90	(2.72)	104.01	(2.96)
Visuospatial Sketchpad						
Block Recall	86.79	(3.47)	97.27	(2.77)	91.01	(3.03)
Pictures Location	9.12	(2.88)	10.15	(2.59)	9.37	(2.48)
Executive Functioning						
Backward Digit Recall	82.55	(2.34)	86.18	(1.86)	89.84	(2.03)
Episodic Buffer						
Recalling Sentences	6.12	(0.46)	9.28	(0.37)	10.51	(0.40)

Dual Processing Task

Dual processing: verbal domain conditions.

The mean spans and 95% confidence intervals for performance on the three verbal domain conditions of the dual processing task are presented in Figure 3.

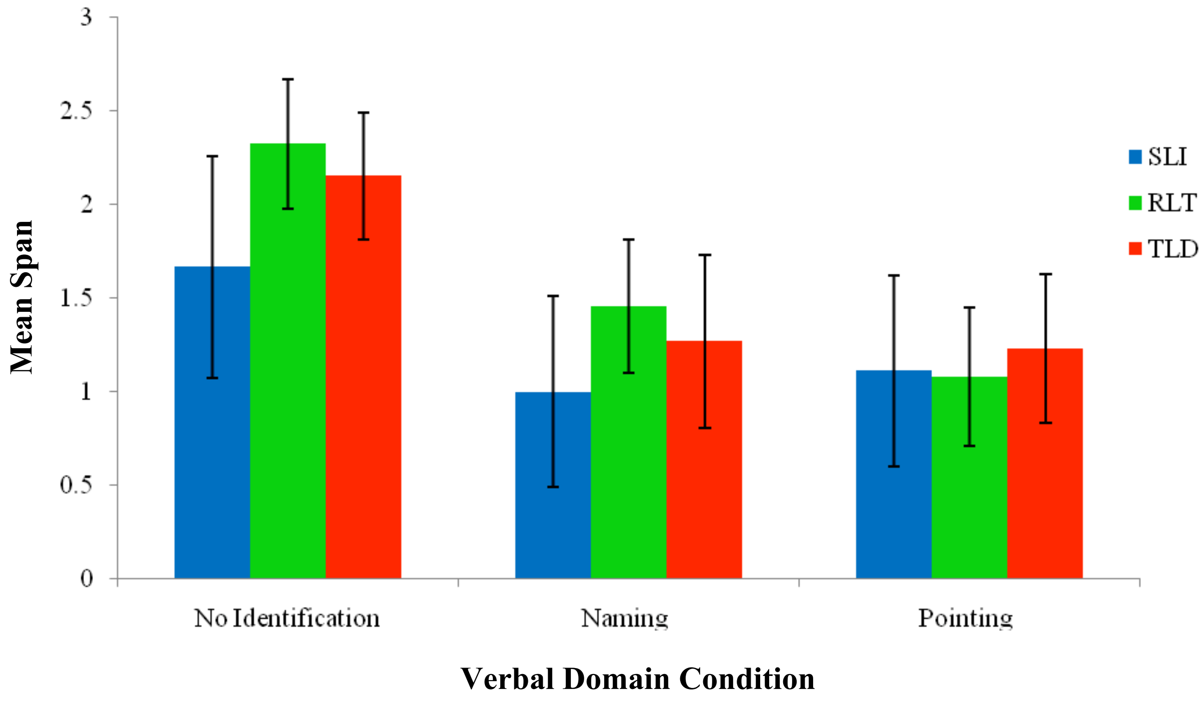

Figure 3. Mean spans and 95% confidence intervals for each of the three verbal domain conditions on the dual processing task by language group.

A 3 (Language Group: SLI, RLT, TLD) x 3 (Verbal Condition: no identification, naming, pointing) mixed-model repeated measures ANOVA was conducted to assess differences between and within groups on each of the three verbal domain conditions of the dual-processing task. No significant interaction was found between group and condition: $F(4, 156) = 1.02$, $p = .40$, $\eta_p^2 = .02$. The effect of group was also not significant: $F(2,78) = 1.45$, $p = .24$, $\eta_p^2 = .04$[3]. Despite non-significant group differences, the mean spans for the SLI group were consistently lower than that of the TLD group across the verbal domain

[3] Separate univariate analyses of covariance were conducted to control for verbal span in the verbal domain, naming condition. Children's performance on the digit recall task and the CNRep (measures of the phonological loop) were used as covariates. Adjusting for verbal span did not alter the results; there were no significant differences between the groups.

conditions[4]. Controlling for nonverbal IQ, as measured by the K-Bit Matrices subtest, did not alter this result; again no significant between-group differences were found across the verbal domain conditions, $F(2, 77) = 1.01$, $p = .34$, $\eta_p^2 = .03$. The main effect of condition, however, was significant, $F(2, 156) = 22.53$, $p < .001$, $\eta_p^2 = .22$, with a medium to large effect size. Pairwise comparisons, using Tukey HSD, revealed that the children had significantly higher mean spans ($M = 2.05$) in the baseline condition than in both the colour pointing condition ($M = 1.14$, $p < .001$) and colour naming condition ($M = 1.24$, $p < .001$). This finding suggests that children recalled significantly more information when no colour identification was required. That is, when there was no dual processing and therefore rehearsal was not impeded by the additional requirement of naming or pointing.

All groups performed near floor levels with the introduction of the colour identification task, which may in part account for the lack of group differences on the verbal domain conditions. On the colour naming condition (same modality), 50% of children with SLI, 32.4% of RLTs, and 44.4% of children with TLD failed to recall a span of two digits. The percentage of children who failed to recall a minimum of two digits on the colour pointing condition (cross modality) was: SLI: 44.4%, RLT: 48.6%, TLD: 38.5%. The largest span achieved by the children across groups was three on the naming condition (achieved by four RLTs and three children with TLD) and four on the pointing condition (achieved by one RLT), with seven being the maximum possible.

Dual processing: spatial domain conditions.

The mean span scores with 95% confidence intervals for each group on the three spatial domain conditions of the dual processing task are presented in Figure 4.

[4] To explore the validity of the verbal domain baseline condition, a correlational analysis was conducted with digit recall. For the total sample, performance on the baseline condition was significantly correlated with scores on the digit recall task ($r = .23$, $p = .04$).

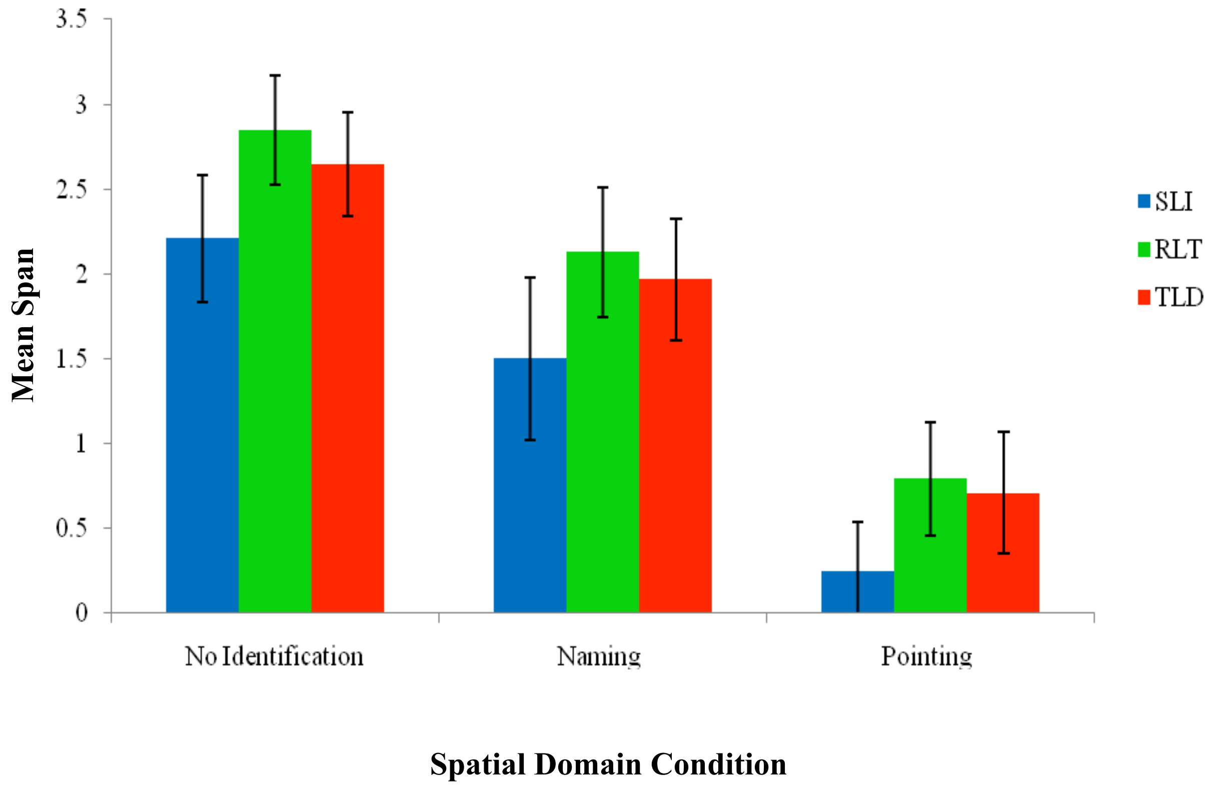

Figure 4. Mean spans and 95% confidence intervals for each of the three spatial domain conditions on the dual processing task by language group.

To examine hypothesis six, that children with SLI would perform significantly poorer than the children with TLD across the three spatial domain conditions, a 3 (Language Group: SLI, RLT, TLD) x 3 (Spatial Condition: no identification, naming, pointing) mixed-model repeated measures ANOVA was conducted, with language group as the between-subjects factor. The analysis revealed a non-significant interaction between language group and condition: F (4, 182) = .05, p = 1.00, η_p^2 = .001. The main effect of group was significant, F (2, 91) = 6.10, p = .003, η_p^2 = .12, with a medium effect size. Pairwise comparisons indicated that the SLI group (M = 1.32) had significantly shorter mean spans than both the RLT (M = 1.92, p = .002) and TLD groups (M = 1.77, p = .04) across conditions. However, when group performance was compared on the individual conditions, with an adjusted alpha level of .017, no group difference reached statistical significance and effect sizes were small: Baseline: F (2, 91) = 3.63, p = .03, η_p^2 = .07; Naming condition: F (2, 91) = 2.45, p = .09, η_p^2 = .05[5]; Pointing condition: F (2, 91) = 2.71, p = .07, η_p^2 = .06. An analysis of covariance was conducted to control for nonverbal IQ, as measured by the K-Bit Matrices subtest, on performance in the spatial domain conditions of the dual processing task. After adjusting for nonverbal cognitive ability, the main effect of group remained significant, $F(2, 90) = 5.51$, p = .006, η_p^2 = .11. An inspection of the adjusted mean scores indicated that, as previously, the SLI group had shorter spans (M = 1.33) than both the RLT (M = 1.91) and TLD (M = 1.79) groups.

A main effect of condition was also significant, F (2, 182) = 116.58, $p < .001$, η_p^2 = .56, with a large effect size. Post hoc Tukey HSD comparisons showed that performance significantly differed across each spatial domain condition. Children recalled the greatest amount of information when no colour identification task was present (baseline condition vs. colour naming condition, $p < .001$; baseline condition vs. colour pointing condition, $p < .001$). Furthermore, recall was superior on the colour naming condition, relative to the colour pointing condition ($p < .001$). That is, children recalled the least amount of information when the stimuli and responses in the recall domain and colour identification tasks tapped the same modality (spatial-spatial)[6].

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[5] Separate univariate analyses of covariance were conducted to control for verbal span in the spatial domain, naming condition. Children's performance on the digit recall task and the CNRep (measures of the phonological loop) were used as covariates. Adjusting for verbal span did not alter the results; in this condition there were no significant group differences.

[6] Demonstrating the validity of the spatial domain baseline condition, performance on the baseline condition was significantly correlated with both measures of the visuospatial sketchpad: Block Recall (r = .50, $p < .001$) and Picture Locations (r = .49, $p < .001$).

Further investigation of performance across conditions revealed that 33.3% of the SLI group had a span of three or more in the baseline condition, as compared to 69.2% of the RLT group and 58.1% of the TLD group. Span for all three groups dropped in the colour naming condition, with only 16.7% of the SLI group achieving a span of three or more, as compared to 30.8% of the RLT group and 29% of the TLD group. When the requirements of the task required simultaneous activation of the spatial response modality (colour pointing condition), all three groups performed near floor level, with 87.5% of the SLI group achieved a span of zero, as well as 61.5% of the RLT group and 64.5% of the TLD group.

As a number of children from all three groups did not complete the verbal domain conditions of the dual processing task, a secondary 3 (Language Group: SLI, RLT, TLD) x 3 (Spatial Condition: no identification, naming, pointing) mixed-model repeated measures ANOVA was conducted with only children who completed both the verbal and spatial domain conditions. The revised sample size for this analysis was 81. As with the larger sample previously discussed, the results of the ANOVA revealed a non-significant interaction between Language Group and Spatial Condition, F (4, 156) = .15, p = 0.96, η_p^2 = .004. A main effect for Language Group was also found, F (2, 78) = 4.39, p = .02, η_p^2 = .10 and as found with the larger sample, pairwise comparisons indicated that the SLI group had significantly shorter mean spans (M = 1.37) than the RLT group (M = 1.95, p = .01) across conditions. However, the mean spatial spans for the SLI and TLD groups (M = 1.72) did not remain significantly different (p = .23). Once again, when group performance was compared on the individual conditions, with an adjusted alpha level of .017, no group difference reached statistical significance and effect sizes were small: Baseline: F (2, 78) = 2.04, p = .14, η_p^2 = .05; Naming condition: F (2, 78) = 1.89, p = .16, η_p^2 = .05; Pointing condition: F (2, 78) = 2.60, p = .08, η_p^2 = .06. A significant main effect for Spatial Condition remained, F (2, 156) = 96.92, p < .001, η_p^2 = .55. Consistent with the findings previously reported, post hoc

Tukey HSD comparisons showed that performance significantly differed on each spatial domain condition ($p < .001$ for all comparisons). Overall, these secondary analyses with a smaller sample showed similar results, with the only significant difference being that children with TLD no longer outperformed children with SLI on the spatial domain conditions.

Further analyses.

In both domains, children had lower span scores in the baseline conditions than in the colour identification conditions; therefore difference scores were calculated between span in the baseline conditions (verbal and spatial) and span in the colour naming and pointing conditions (See Table 6). These scores were calculated to examine the impact of dual-task processing on recall.

Table 6

Mean Difference Scores and Standard Deviations on the Verbal Domain and Spatial Domain Conditions by Group

	SLI		RLT		TLD	
	M	*(SD)*	*M*	*(SD)*	*M*	*(SD)*
Verbal Domain						
Baseline – Naming	0.67	(1.49)	0.86	(1.42)	0.88	(1.39)
Baseline - Pointing	0.55	(1.20)	1.24	(1.26)	.92	(1.05)
Spatial Domain						
Baseline – Naming	0.71	1.12	0.72	1.23	0.68	1.16
Baseline - Pointing	1.96	(1.30)	2.05	1.17	1.93	0.93

One-way ANOVAs were conducted on the difference scores. Looking at the verbal domain conditions first, there were no significant between-groups differences on either the baseline - colour naming (same modality) difference scores, $F\ (2, 80) = 0.18$, $p = .83$, $\eta_p^2 = .005$, or the baseline - colour pointing (different modality) difference scores, $F\ (2, 78) = 2.10$, $p = .13$, $\eta_p^2 = .05$. Similarly, within the spatial domain, there were no significant between-groups differences on either the baseline – colour naming (different modality) difference scores, $F\ (2,91) = 0.01$, $p = .99$, $\eta_p^2 < .001$, or the baseline – colour pointing (same modality) difference scores, $F\ (2, 92) = 0.10$, $p = .90$, $\eta_p^2 = .002$. These results show that, across the verbal and spatial domains, all groups were similarly affected by demands of dual processing.

The analyses presented above investigated performance within each domain only. To explore differences in recall across the domains, a 3 (Language Group: SLI, RLT, TLD) x 2 (Domain: verbal and spatial) x 3 (Condition: no identification, naming, pointing) mixed-model repeated measures ANOVA was conducted, with group as the between-subjects variable. Only cases with data available in each condition were included in the analyses (n = 81). A significant two-way interaction between domain and condition was found: $F(2, 156) = 20.69$, $p < .001$, $\eta_p^2 = .21$. An analysis of simple main effects revealed that the RLT group recalled significantly more spatial information (M = 1.95) than verbal information (M = 1.62): $F(1, 78) = 6.27$, $p = .01$, $\eta_p^2 = .07$. Performance of the SLI (M verbal = 1.26, M spatial = 1.37; $p = .56$) and TLD (M verbal = 1.55, M spatial = 1.72; $p = .30$) groups did not differ across domains.

To explore the interaction between domain and condition, paired-samples t-tests were used to compare performance across the verbal and spatial domains on each colour identification condition. An adjusted error rate of .025 was used. In the baseline conditions, both the SLI (Spatial: M = 2.39; Verbal: M = 1.67, $t(17) = 3.20$, $p = .005$) and RLT groups (Spatial: M = 2.89; Verbal: M = 2.32, $t(36) = 2.61$, $p = .01$) had significantly larger spatial spans than verbal spans, but this was not so for the TLD group (Spatial: M = 2.58; Verbal: M = 2.15, $t(25) = 1.66$, $p = .11$). In the colour pointing (spatial) conditions, performance was significantly poorer in the spatial domain than in the verbal domain for both the SLI (Spatial: $M = 0.22$; Verbal: $M = 1.11$, $t(17) = 3.69$, $p = .002$) and TLD groups (Spatial: $M = 0.69$; Verbal: $M = 1.23$, $t(25) = 2.57$, $p = .002$). That is, children in the SLI and TLD groups had larger spans when the recall and colour identification tasks crossed domains and smaller spans when the domains were the same. Meanwhile, in the colour naming conditions, the RLTs achieved a larger span in the spatial domain (cross modality), relative to the verbal domain (same modality): Spatial: $M = 2.13$; Verbal: $M = 1.46$, $t(36) = 2.72$, $p = .01$. No further significant differences were found.

Relationships among the Working Memory Measures

Person product-moment correlations were conducted to investigate hypothesis seven, that there would be significant associations amongst the variables measuring each component of working memory. The correlation coefficients are presented in Table 7. As there were no significant differences between the RLTs and children with TLD on any measure of working memory, these two groups were collapsed into one group, representing children with language abilities within the normal range at age 4 years.

Table 7

Pearson Product-Moment Correlations between the Measures of Working Memory for the SLI Group and the RLT+TLD Group

Measure	1	2	3	4	5	6	7
SLI (*n* = 21)							
1. Digit Recall	-	-.06	.19	.13	.32	.40	.24
2. Word List Recall		-	.33	.30	.08	.29	.07
3.CNRep			-	.27	.43	.70**	.60**
4. Block Recall				-	.55**	.12	.42
5. Picture Locations					-	.17	.42
6. Recalling Sentences						-	.49*
7. Backward Digit Recall							-
RLT + TLD (*n* = 68)							
1. Digit Recall	-	.19	.35**	.06	.03	.54**	.43**
2. Word List Recall		-	.21	.14	.03	.24	-.07
3.CNRep			-	-.12	.05	.38**	.13
4. Block Recall				-	.26*	-.03	.20
5. Picture Locations					-	.08	.16
6. Recalling Sentences						-	.40**
7. Backward Digit Recall							-

Note. * $p < .05$ two-tailed. **$p < .01$ two-tailed.

Consistent with hypothesis seven, in both groups, performance on the two measures of the visuospatial sketchpad (Block Recall and Picture Locations) was significantly correlated (SLI, $r = .55$, $p < .01$, and RLT+TLD, $r = .26$, $p = .03$). Contrary to expectations, in the SLI group the three phonological loop measures were only weakly related to one another, with *r* values ranging from -.06 (Digit Recall and Word List Recall) to .33 (Word List Recall and CNRep). In contrast, for the RLT+TLD group, two measures of the phonological loop were correlated ($r = .35$, $p < .01$); better performance on the digit recall task was moderately associated with better nonword repetition. In addition, better digit recall was also associated with better performance on the measure of the episodic buffer (Recalling sentences; $r = .54$, $p < .001$) and on the central executive task (Backward digit recall; $r = .43$, $p < .001$) for the RLT+TLD group, but not for the SLI group. For both groups, performance on the nonword repetition task was significantly correlated with performance on the recalling sentences task (SLI, $r = .70$, $p < .001$, and RLT+TLD, $r = .38$, $p < .01$) and, for the SLI group only, nonword repetition was strongly correlated with performance on the backward digit recall task ($r = .60$, $p < .01$). Lastly, in both groups the measure of the episodic buffer was moderately correlated with the measure of the central executive (SLI, $r = .49$, $p = .02$, and RLT+TLD, $r = .40$, $p < .01$).

Discussion

The purpose of this study was to examine the different components of Baddeley's working memory model (Baddeley, 1986, 2000) in three groups of 5-year-old children: children with SLI, children performing within average limits on standardised language measures, despite a history of early expressive language delay (RLTs) and typically developing children. The results are considered in relation to the hypotheses.

Phonological Loop

Hypothesis one predicted that the children with SLI would have significantly lower scores than the children with TLD on the two measures of phonological memory, digit and word list recall, and that the RLT group would perform significantly better than the SLI group, but not as well as the TLD group on these measures. Consistent with this hypothesis, the children with SLI performed significantly poorer than both the RLTs and children with TLD on digit recall. However, the RLT and TLD groups performed comparably, which was not the predicted result. Furthermore, there were no significant group differences on word list recall. The weak correlations found between the digit recall and word list recall tasks suggest that these tasks tap different skills in 5-year-old children.

The results from the digit recall task support previous findings that children with SLI have markedly limited phonological working memory capacity to process and store phonological input, which impacts on their language development (e.g., Archibald & Gathercole, 2006b; 2007a; Bishop, et al., 1996; Conti-Ramsden, 2003; Gathercole & Baddeley, 1990; Hick, et al., 2005a). In contrast, despite early language delay, RLTs do not necessarily show deficits in phonological loop capacity at age 5 years. The lack of group differences on word list recall in the current study is inconsistent with previous research on SLI (Briscoe & Rankin, 2009; Dodwell & Bavin, 2008). On the basis of impairments relative to chronological age (scores below 1 standard deviation of the population mean), Archibald and Gathercole (2006b) demonstrated deficits in the performance of children with SLI on both digit and word list recall. As discussed in the introduction, 60% of the children with SLI in that study scored at least 1 standard deviation below the mean on digit recall and 70% on word list recall. This is a much higher percentage than in the present study, with 29.2% of the children with SLI scoring at least 1 standard deviation below the mean on both digit recall and word list recall. Unlike the current study, Archibald and Gathercole did not compare the performance of children with SLI with that of typically developing children. The differing results might be explained by the age of the children. In the current study children were younger than those in the Archibald and Gathercole study, approximately four years younger, and younger than those in the other studies previously discussed. The SLI group scored lower than both the TLD and RLT groups on word list recall, although differences were not significant. Because, as Luciana and Nelson (1998) argue, memory develops between the ages of 4 and 8 years, it is likely that significant group differences on word list recall would become more apparent as verbal span increases.

Nonword repetition is commonly used to measure phonological memory capacity in young children as the repetition of nonwords requires greater reliance on the temporary storage of phonological representations than items such as words or digits (Archibald & Gathercole, 2007b; Gathercole & Baddeley, 1989). Impaired nonword repetition of children with SLI relative to their typically developing peers in the current study supports hypothesis two and adds to previous research which has consistently reported deficits in nonword repetition for children with SLI (e.g., Archibald & Gathercole, 2006c; Briscoe & Rankin, 2009; Dollaghan & Campbell, 1998; Gathercole & Baddeley, 1990; Montgomery & Evans, 2009; Redmond, Thompson, & Goldstein, 2011). Consistent with past research, children with SLI demonstrated significant difficulty repeating long (four and five syllable) nonwords compared to short nonwords (two and three syllables), reflecting their limited phonological working memory capacity (Gathercole & Baddeley, 1990). This finding lends support for a phonological memory deficit in SLI. While short nonwords are not sufficient to overwhelm working memory span, long nonwords may surpass phonological working memory resources, resulting in difficulties in encoding phonological representations and maintaining these representations in working memory. However, as discussed in the introduction, successful nonword repetition involves a number of additional processes, including speech perception, phonological encoding and assembly, phonological knowledge, motor planning, and articulation (Coady & Evans, 2008). For instance, children hearing a new word must first perceive and encode the sequence and then be able to hold the sequence in a temporary memory store with a robust enough representation to support further processing, articulation, and connection to meaning (Graf Estes, Evans, & Else-Quest, 2007). Children with SLI may experience deficits at any point, or multiple points in this process.

Although the RLT group had a higher mean accuracy in repeating nonwords than the children with SLI and a lower mean accuracy than the TLD group, their performance on the CNRep was not significantly different from either group. This finding is in contrast to the findings of Thal and colleagues (2005) and Bishop and colleagues (1996), who found that children with a history of language delay, aged 4 years and 7- to 9-years, respectively, had impaired performance on a nonword repetition task. The discrepancy in findings may be influenced by the different criteria used to identify children with a history of language delay. Bishop et al. classified children with a history of early language delay if they had attended regular speech-language therapy for at least one year. In the current study, children were not a clinical sample but were identified as late talkers at 24 months if the number of words produced was at or below the 10th percentile on the CDI (Fenson, et al., 1993), a standardised parent report measure. Thal and colleagues identified late talkers at the younger age of 16 months using the CDI. As suggested by Ellis Weismer (2007), the age at which late talkers are identified is an important consideration. While children in Thal et al.'s study did not have impaired language at age 4 years, they did score significantly lower than the TLD group on the CELF-P (Wiig, Secord, & Semel, 1992) Receptive and Expressive Language scales. Furthermore, group differences were found on the measure of cognitive processing, Kaufman Assessment Battery for Children (K-ABC; Kaufman & Kaufman, 1983). In contrast, in the current study the RLT and TLD groups performed comparably on the CELF-P2 (Wiig, et al., 2006) Expressive and Receptive scales, as well as on the measure of nonverbal cognitive ability, the K-Bit (Kaufman & Kaufman, 2004). Of note, no child with TLD recorded a standard score below 90 on the K-Bit, but two children from the RLT group and two children with SLI recorded scores between 85 and 89. In addition, it must be pointed out that even though the RLT group had comparable nonverbal abilities compared to the SLI and TLD groups, they did have higher mean scores than these two groups. However, controlling for the influence of nonverbal cognitive abilities in a covariate analysis did not alter the results on the CNRep. Overall, the children with a history of language delay in Thal et al.'s study and our group of RLTs may not represent the same population of children. Identification of late talkers in the two studies depended on parent reports, and while the CDI is a standardised and reliable instrument there is variability in parents' responses, which may be reflected in different populations of children. For example, in a recent study using the CDI modified for Australian English as in the current study, Bavin et al. (2008) found lower vocabulary scores for children aged 1;0 and 2;0 than those reported in the CDI norming study (Fenson, et al., 2007). Hamilton, Plunkett, and Schafer (2000) reported similar findings with British children using a British adaptation of the CDI; the children had lower scores on both comprehension and production than American children of the same age. These results suggest that either cultural differences affect the rate of vocabulary development or that parents underestimate their child's language skills in some groups. In summary, the current findings show that despite an early history of language delay, our RLTs were performing within the normal limits on measures of phonological memory at 5 years of age.

Visuospatial Sketchpad

Hypothesis three predicted that the performance of the children with SLI would be poorer than that of the TLD group on two visuospatial tasks included to test the visuospatial sketchpad component of Baddeley's model of working memory (Baddeley, 2000; Baddeley & Hitch, 1974): block recall and picture location. The results did not provide support for this hypothesis. The children with SLI showed no significant differences in accuracy relative to the TLD group. Although this result was not predicted, findings regarding visuospatial working memory in children with SLI have been mixed. Recall that children with SLI have been found to exhibit significant deficits in spatial span (Bavin, et al., 2005; Hick, et al., 2005b). In some previous studies visuospatial tasks have also tested capacity limitations rather than span, as in cross-modal verbal-spatial and dual processing tasks (Hoffman & Gillam, 2004) or they involve a learning component as in the CANTAB task of paired associates learning (e.g., Bavin, et al.). Previous research has also demonstrated that children with SLI may follow a different developmental pattern of visuospatial memory than typically developing children. Hick et al. (2005a) showed slower development on a visuospatial memory task (pattern recall) in children with SLI, aged 3;9, relative to children with TLD over one year. It is also possible that SLI is a heterogeneous group and that some children with SLI experience motor impairments or attentional limitations. Therefore, visuospatial memory tasks varying in the demands placed on children's motor skills and attentional load may result in inconsistent findings.

The current findings are consistent with the findings of Archibald and Gathercole (2006a) who found no significant differences between children with SLI and children with TLD, aged 7 to 12 years, on visuospatial short-term and working memory tasks, which were subtests of the PC-based Automated Working Memory Assessment. Additionally, Briscoe and Rankin (2009) did not find significant group differences on the block recall subtest of the WMTB-C (a task in the current study) in children aged 7 to 9 years, 8 months. The differences across study findings undoubtedly result from the differences in the nature of the tasks (e.g., involvement of executive functions; Marton, 2008), criteria for identifying SLI, and age ranges.

In the current study, it initially appeared that the RLTs outperformed children with SLI on one of the measures of visuospatial memory, block recall, whereas the SLI group and the TLD group performed comparably. However, further analyses revealed that the between-group difference was attributed to the individual children's nonverbal intelligence as measured by the K-Bit Matrices subtest. When nonverbal ability was taken into account, children with SLI and RLTs demonstrated comparable performance on measures of the visuospatial sketchpad.

Episodic Buffer

Hypothesis four predicted that children with SLI would have significantly lower scores than the TLD group on the measure of the episodic buffer: recalling sentences. Additionally, if there are residual effects of late-talking status, it was predicted that the RLT's would perform significantly better than the SLI group, but not as well as the TLD group on this task. As hypothesised, the SLI group had significantly lower scores than the other two groups. Because poor recalling sentence performance in SLI has been reported in a number of studies (e.g., Laws & Bishop, 2003; Norbury, Bishop & Briscoe, 2001; Redmond, et al., 2011), it has been suggested as a clinical marker for SLI (Archibald & Joanisse, 2009; Conti-Ramsden, et al., 2001). For all three groups of children, the recalling sentences scores correlated with measures of the phonological loop (nonword repetition and digit recall) as well as with the measure of the central executive. This is not unexpected as the task requires the processing, storing and rehearsal of information, as well as the integration of representations from working memory and long-term memory (Baddeley, 2000).

The second part of hypothesis four, that the RLTs would have lower levels of performance on the recalling sentences task relative to the TLD group, was not supported. No significant difference was found between the RLT and TLD groups. This finding provides no evidence for deficits in retaining verbal information whilst accessing stored linguistic material in RLTs. In her longitudinal study, Rescorla (2002) found that, at age 6 years, late talkers performed significantly poorer than typically developing children on a sentence imitation task. However, the late talkers in Rescorla's study were not separated into subsamples of RLTs and children with SLI at age 6 years, as in the current study. The late talkers in Rescorla's study continued to have lower scores on most language measures than the comparison children, and 6-17% of the late talkers (depending on the criterion used) appeared to manifest SLI.

Central Executive

The fifth hypothesis that children with SLI would perform significantly poorer than the TLD group on the verbal central executive task, backward digit recall, and that the RLT group would perform significantly better than the SLI group but not as well as the TLD group, was not supported. Although the mean score for the SLI group was lower than that of the RLT and TLD groups, there were no significant group differences. Briscoe and Rankin (2009), with children aged 7 years to 9 years, 8 months, and Archibald and Gathercole (2006b), with children aged 7 to 9 years, found that children with SLI have markedly depressed verbal central executive functioning. However, in the current study, the children were younger than those in the other two studies and while number knowledge was not tested as such in the current study, it was observed that a number of the 5-year-old children from each group did not have good knowledge of basic numbers. Eight children with SLI, four RLTs and five children with TLD had difficulty counting from one to 10 or could not identify some of the numbers. Furthermore, successful backward digit recall requires processing of verbal information (reversing the order of digits) as well as the retention of the digits (Best & Miller, 2010) and the substantial processing load of the task clearly affected the performance of many of the 5-year-old children in the current study, resulting in all three group means falling below the standardised mean.

Montgomery and Evans (2009) found that, similar to typically developing children, the attentional resource capacity and allocation mechanisms of the central executive in children with SLI improve during their school years. In a review article, Best and Miller (2010) stated that the developmental trajectory of the central executive of working memory is linear with continued maturation through adolescence, especially for more complex tasks that require a greater degree of processing such as the maintenance and manipulation of multiple stimuli. Regardless of the domain (e.g., verbal vs. visuospatial), the developmental course of the central executive depends on the cognitive demands (or the amount of processing) of the task, with less demanding tasks being mastered earlier in development. Therefore, 5-year-old children, both with early language delay and typical language development may have few resources available to successfully allocate their attentional resources simultaneously to verbal processing and storage during complex memory tasks. Given the degree of processing, it would be expected that group differences would emerge in time with the backward digit recall task (Best & Miller, 2010). Overall, these findings suggest that backward digit recall may not be a discriminatory tool at such a young age.

Dual-Processing Task

The results of the study provided partial support for the sixth hypothesis, that there would be a significant difference between the SLI and TLD groups on both the spatial domain and the verbal domain conditions of the dual processing task. Consistent with the hypothesis, children with SLI performed significantly poorer than both the children with TLD and RLTs across the spatial domain conditions. While the mean spans of the children with SLI were always smaller than those of the children with TLD on the verbal domain conditions, no significant group differences were found. Within the verbal domain, the three groups of children did not differ in any of the three conditions, but recall that 14 children (six children with SLI, two RLTs and six children with TLD) were not tested on all verbal domain conditions because they were unable to read the numerals one through nine.

The absence of significant group differences on the verbal domain conditions was inconsistent with the findings of Hoffman and Gillam (2004), who found that children with SLI recalled less information than their peers with TLD across all verbal conditions.

However, the mean age of the children with SLI in their study was 9;5 years, approximately four years older than the children in the current study. The highest mean span achieved by the typically developing children in the current study was on the verbal baseline condition (*M* = 2.15), with seven being the largest span that could have been reached. Typically developing children in Hoffman and Gillam's study achieved a mean span of 4.64 on the same condition. Based on Hoffman and Gillam's findings, it would be predicted that as working memory develops and variability decreases, differences between the SLI and TLD groups would become evident. Interestingly, while children with SLI recalled significantly fewer digits than children with TLD and RLTs on the digit recall task, the groups of children performed comparably on the verbal baseline condition. This could be attributed to the different modalities in which the digits were presented. In the digit recall task, digits were presented in the auditory domain, whilst in the verbal baseline condition the digits were presented visually. Consistent with this, whilst the two tasks were significantly correlated, the strength of the correlation was small to moderate. Archibald and Gathercole (2007a) found similar results in their research; children with SLI aged 7- to 12-years performed significantly poorer than the age-matched typically developing group on an auditory digit recall task, but performed comparably on a verbal storage task, in which sequences of digits were presented visually. Archibald and Gathercole proposed that children with SLI can to some degree compensate for their limited phonological memory capacity when stimuli are presented in the visual domain.

Within the verbal domain, the three groups of children had significantly poorer performance when the recall condition was paired with an additional colour identification task. Regardless of the type of colour identification task, verbal recall was impaired with the increased cognitive load. That is, the additional task impeded rehearsal. When the amount of information to be processed increased, all of the children had difficulty co-ordinating information processing resources, a function of the central executive in working memory (Hoffman & Gillam, 2004).

The lack of group differences on the verbal domain conditions in the current study can also be, in part, explained by methodological limitations. A number of children from each group did not complete the verbal domain conditions due to not being able to read numbers one to nine, and as noted above, children who did complete the task performed near floor levels. The requirements of the verbal domain conditions appeared to exceed the abilities of the 5-year-old children in the current study who have not commenced, or have just entered into, formal schooling. To modify the task for younger children, pictures of common farm animals could be used, rather than numbers, as stimuli.

Consistent with the findings of Hoffman and Gillam (2004), children with SLI recalled significantly less spatial information than both the RLTs and children with TLD across all three spatial recall conditions. The impaired performance on these tasks indicates a problem with nonverbal working memory for children with SLI. Although the three groups of children performed comparably on the two measures of the visuospatial sketchpad (block recall and picture locations), group differences emerged on tasks that placed greater demands on the central executive. Archibald and Gathercole (2007a) also found that children with SLI were significantly impaired on a visuospatial processing task, relative to their typically developing peers, but not on a visuospatial storage task. These findings suggest that the nature of the task determines the extent to which children with SLI show impaired visuospatial working memory. Of note, when these analyses were performed with a smaller sample of children, excluding 14 children who did not complete the verbal domain conditions, the significant group difference between children with SLI and those with TLD did not remain significant. Furthermore, on the individual spatial domain conditions, no group difference between the three groups of children remained statistically significant.

Given these inconsistent findings, further research is warranted with children in this young age range on spatial dual-processing tasks that are suitable for young children.

Superior spatial recall of the RLTs on the spatial domain conditions, relative to the children with SLI suggests that the visuospatial working memory abilities of RLTs are largely unimpaired. In fact, further analyses revealed that the RLTs had superior performance in the spatial domain conditions, relative to the verbal domain conditions. Furthermore, the children with SLI and RLTs had greater spatial spans than verbal spans in the baseline conditions of the dual processing task. In contrast, performance of the children with TLD was comparable across the domains on the baseline condition. Together these findings suggest visuospatial working memory is more developed than phonological working memory in 5-year-old children with a history of early language delay.

Lastly, children from each group benefited from the opportunity to disperse information processing efforts across the verbal and spatial domains. For instance, as found by Hoffman and Gillam (2004) with older children with SLI and TLD, the poorest performance of all three groups in the current study was in the spatial domain, colour pointing (spatial) condition. That is, the children recalled the least amount of information when the stimuli and response modalities in the recall and colour identification tasks were the same. Recall of visuospatial information (e.g., location of X's) relies on the rehearsal of information in the visuospatial sketchpad and this rehearsal is interrupted when one is required to simultaneously carry out another task in the same domain (e.g., colour pointing condition). This condition was difficult for each group of children, with the children performing near floor levels. Of note, for the SLI group only, performance in this condition was found to be positively skewed. As Gathercole and colleagues (Gathercole, Pickering, Ambridge, & Wearing, 2004) argue, the basic structure of working memory is present from 6 years of age and possibly earlier, although the functional capacity of each component increases linearly from age 4 years to early adolescence (Luciana & Nelson, 1998).

Relationships between the Measures of each Component of Baddeley's Model of Working Memory

The results of this study provided partial support for the seventh hypothesis that there would be significant associations between the measures of working memory. Consistent with the hypothesis, the two measures of the visuospatial sketchpad were significantly correlated, indicating that, at some degree, the tasks are tapping the same construct of working memory. For the RLT+TLD group, a moderate relationship was found between two phonological measures, digit recall and nonword repetition. Across the groups, moderate to large significant correlations were found among the measures of the phonological loop, central executive, and episodic buffer. The strength of such correlations indicates that while these tasks are all tapping into working memory, they do measure different aspects. Working memory develops during early childhood and into adolescence and the lack of further significant correlations among tasks assumed to tap the same construct of working memory (e.g., word list recall and digit recall) may be because the constructs are not well developed in 5-year-old children or these particular children. Furthermore, the lack of significant correlations between word list recall and digit recall might result from the more complex semantic aspects of words.

Conclusion

The results of the study showed depressed performance in children with SLI across measures of phonological loop capacity, with the exception of word list recall, and the episodic buffer. The results add further support to impaired sentence recall and nonword repetition serving as useful clinical markers of persistent language impairment as seen in SLI. The results did not show deficits for children with SLI on tasks assessing the visuospatial sketchpad. However, impaired visuospatial working memory was found in children with SLI in tasks tapping into the central executive component of working memory. Concurrent rehearsal of spatial information was found to negatively impact on performance on the dual processing task, suggestive of visuospatial capacity limitations in children with SLI. On the measure of central executive, performance by children with SLI was not different from that of the TLD group; however, this was explained by the fact that many of these 5-year-olds from all three groups were not too familiar with their numbers. Thus, backward digit recall task is not a recommended tool for discriminating groups at this age.

Despite early language delay, the RLTs did not show deficits in working memory, in comparison to children with TLD, at age 5 years. Of note, the current study identified an advantage in the storage and processing of visuospatial material, relative to phonological material, in RLTs. Differences found in previous studies with RLTs may be accounted for by different populations of children, from late bloomers who start late but catch up quickly to late talkers with more persistent delays. Research has documented that late talkers constitute a heterogeneous group. Those late talkers who catch up may have a history of limited social skills and internalized behavioural problems, such as withdrawal (Desmarais, et al., 2008). This was not investigated in the current study. Of note, it is significant that in this study the RLTs had superior performance on measures of the phonological loop, episodic buffer, and visuospatial working memory relative to children with SLI. Future research is needed to determine the generalisability of these differences.

CHAPTER 6

STUDY TWO

Introduction

The narrative abilities of children with SLI have been well researched as discussed in Chapter 4. However, large age ranges and the variability in narrative tasks have resulted in conflicting findings. For example, Norbury and Bishop's (2002) study showed no significant difference between 16 6- to 10-year-old children with SLI and 18 of their typically developing peers of comparable age on the recall of a narrative they had heard. However, Dodwell and Bavin's (2008) research found that 16 6- to 7-year-old children with SLI performed significantly worse than their peers in recalling a narrative they had heard; although this was not the case when recalling a narrative that they had generated themselves. Research has implicated working memory in the recall and comprehension of narratives. However, to the author's knowledge, only one study has investigated the associations between working memory and narrative abilities in children with SLI (Dodwell & Bavin, 2008) and, as discussed in Chapter 4, very little research has been conducted comparing the narrative abilities of RLTs with those of children with SLI. In order to further our understanding, this study was designed to compare the narrative abilities of 5-year-old children with SLI, RLTs, and typically developing children.

Narrative abilities were measured using the ERRNI Fish Story (Bishop, 2004). In contrast to an assessment tool that requires a child to retell a story first related by an adult (e.g., the Birthday Story; Culatta, Page, & Ellis, 1983), the ERRNI story assesses the child's ability to generate and organise a narrative without an adult model. This provides a somewhat more realistic impression of the child's planning and expressive language abilities (Norbury & Bishop, 2003). Furthermore, the use of wordless picture books, such as the

ERRNI Fish Story, reduces the cognitive demands required to construct a complex oral narrative without prompts (Hudson & Shapiro, 1991).

Aims and Hypotheses

The first aim of the study was to investigate the narrative abilities of 5-year-old children with SLI in relation to typically developing children and a group of RLTs. Given the established links between memory and language development, the second aim was to examine the relationships among working memory measures from Study One and measures of narrative performance from this study. That is, the current study explored the extent to which working memory abilities are involved in the higher order language skills of narrative generation, comprehension, and recall.

Based on previous research five hypotheses were formulated:

i. Based on the findings from Dodwell and Bavin (2008), Norbury and Bishop (2002; 2003), and Paul and colleagues (1996), the first hypothesis predicted that all three groups of children (SLI, RLT, TLD) would produce a similar number of main ideas when generating and recalling a narrative.

ii. Based on the findings of Dodwell and Bavin (2008), it was predicted that children with SLI would not be disadvantaged on literal comprehension questions, but would perform significantly poorer than both the TLD and RLT groups on inferencing questions.

iii. Based on the links between language comprehension and expression, it was hypothesized that there would be significant correlations between the measures of narrative generation, recall, and comprehension.

iv. Given that narrative tasks involve the storage and integration of information, it was expected that the measures from Study One of the four components of working memory, the phonological loop, visuospatial sketchpad, central executive, and episodic buffer, would be significantly correlated with the narrative measures.

v. Based on the work of Montgomery, Polunenko, and Marinellie (2009) with typically developing children, it was predicted that performance on the verbal domain conditions of the dual-processing task from Study One would be significantly correlated with ERRNI comprehension.

Method

Participants

The sample from Study One was also used for Study Two, and as such recruitment procedures and inclusion and exclusion criteria are identical to those in Study One and are not presented again here. As per Study One, 24 children with SLI, 39 RLTs, and 32 children with TLD participated in the current study (see Chapter 5 for the participant demographic and screening descriptive statistics).

Materials

Expression, Reception and Recall of Narrative Instrument (ERRNI): To examine language skills in the context of narrative generation and comprehension, as well as, the recalling of a story, the Fish Story of the ERRNI (Bishop, 2004) was used. The Fish Story is displayed as a series of 15 pictures three to a page on five pages, which are bound into a book. The pictures represent a story about a switch: a boy buys a fish from the pet shop and on the way home he meets two friends one of whom secretly swaps the fish for a doll from the other friend's bag. When the boy gets home and discovers the doll, his mother telephones the friends and they come over to exchange the doll and fish (See Appendix E for a description of the 15 pictures). Children are required to make some inferences about the knowledge of a number of characters in the story.

Following test protocol, the child looks through the pictures before and during initial story-telling. Then after 20 minutes, without warning, the child is asked to recall the narrative with the instruction, "You remember that story you told me about the boy and his fish? I want to see how much of it you can remember. Tell me the story again now, without looking at the pictures. Tell me as much as you can." If the child is unable to recall anything, then a prompt is given, "What did the boy do at the start of the story?" The child is then asked nine comprehension questions, six of which test the child's ability to infer what was not directly depicted.

Procedure

The ERRNI task was administered in conjunction with the test battery administered in Study One. The generation component was administered at the start of the session and the recall and comprehension components were administered after 20 minutes, following tasks from the WMTB-C (Pickering & Gathercole, 2001).

Following test protocol, a warm-up task was administered, in which the child was asked to tell the experimenter as much as he/she could about a picture of children at a swimming pool. The aim of the warm-up picture was to encourage children to talk about pictorial material. Before the child was asked to narrate the picture book to the experimenter, he/she was given time to look through the book. The book remained opened in front of the child during the generation of the narrative. Responses were audio taped for transcription and scoring. Following approximately 20 minutes, the child's recall of the narrative was assessed. In accordance with test protocol the child was asked to recall the story they had generated during the initial story-telling. Again, the child's response was audio taped for transcribing and scoring. Prompting during narrative generation and recall was restricted to general encouragement and if necessary nonspecific prompts such as, "What happened next?". Once the child had recalled the story he/she was asked nine comprehension questions. Their responses were written down and also audio recorded to allow for clarification.

An information index was used to score the child's generated and recalled story, creating the dependent variables ERRNI Initial-Story Generation and ERRNI Recall, respectively. For initial-story generation and recall, scores of zero, one, or two were awarded for each of the 24 listed items (i.e., ideas from the story) with a maximum score of two for any one item (total maximum score = 48). The manual clearly specifies what counts for zero, one, and two points. The raw scores for initial-story generation and recall were converted into standard scores. Each comprehension question had a minimum score of minus one and maximum score of two and the total raw score (total maximum score = 18) was converted into a standard score, creating the dependent variable of ERRNI Comprehension. Two points were awarded for a correct response that provided all of the relevant details, and one point was awarded if a piece of salient information had been omitted. In line with standard ERRNI procedures, a point was deducted if the child included additional incorrect information or used imprecise vocabulary. The maximum possible score was 12 for the inferencing questions and six for the literal questions. The inferential comprehension questions were further divided into three types: two involving gap-filling inferences, two involving theory of mind, and two involving emotional inferencing. Gap-filling inferences required children to integrate their own general knowledge with information in the text to fill in details that were not explicitly stated (e.g., *Who is the mother talking to on the phone?*), whilst inference questions addressing theory of mind required children to infer the mental states, particularly thoughts and expectations, of the characters (e.g., *What did the girl think was in her yellow bag?*). Children were also required to infer the mood or emotional state of a story character (e.g., *How did the boy feel when he found the doll?*).

Results

Results are presented in the following order: Firstly, the results from the ERRNI generation and recall tasks are discussed, followed by those from the ERRNI comprehension questions. The relationships among the measures of comprehension, narrative generation, and recall for each group are then discussed. Lastly, the results from the correlation analyses of the narrative and working memory measures from Study One are presented.

Group differences were investigated using one-way ANOVAs and when significant group effects were found, post hoc Tukey HSD tests were performed. As for Study One, effect sizes for main effects are reported using partial eta squared (η_p^2). For η_p^2, .01 is considered a small effect size, .09 a medium effect size, and .25 a large effect size (Cohen, 1988). For post hoc pairwise comparisons, effect sizes are reported using Cohen's *d*: small, *d* = .2; medium, *d* = .5; large, *d* = .8. The sizes of correlations are also interpreted as in Study One: small, *r* = .10 to .29; medium, *r* = .30 to .49; large *r* = .50 to 1.0 (J. Cohen, 1988, pp. 79-81).

Two children (1 RLT, 1 TLD) were shy towards the examiner and chose not to answer the comprehension questions and a further two children (1 SLI, 2 RLT, 1 TLD) did not want to tell a narrative or recall it after a delay due to shyness or noncompliance. Normality of distribution was assessed with standardized indices (*z*) of skewness and kurtosis as described for Study One (Chapter 5). The ERRNI Recall standard scores for the RLT and TLD groups were positively skewed and three outlying cases were identified in these groups; two outliers were detected in the RLT group and another in the TLD group. The outlying scores were all upper bound and therefore moved to the next highest possible score in the distribution plus one (Tabachnick & Fidell, 2007, p. 77). Following the adjustment of these outlying values, this variable met the requirement of normality within the boundary limits of z = ± 3.30. Two upper bound outliers were also identified in the RLT group on ERRNI

Initial-Story Generation. To reduce the impact of these outliers, the outlying score was moved to the next highest possible score plus one. The mean standard scores, standard deviations, and range of scores for the ERRNI narrative variables: Initial-Story Generation, Recall, and Comprehension are shown in Table 8.

Table 8

Mean Standard Scores, Standard Deviations and Range of Scores for ERRNI Initial-Story Generation, Recall and Comprehension

	SLI		RLT		TLD	
	M	*(SD)*	*M*	*(SD)*	*M*	*(SD)*
Measure	[Min – Max]		[Min – Max]		[Min – Max]	
Initial-Story Generation	93.48	(11.62)	101.65	(11.80)	100.97	(12.85)
	[77 – 116]		[82 – 124]		[80 – 123]	
Recall	88.74	(4.30)	97.16	(10.71)	94.35	(10.40)
	[82 – 96]		[86 – 120]		[82 – 118]	
Comprehension	84.96	(11.84)	98.76	(15.75)	102.06	(19.01)
	[65 – 103]		[65 – 128]		[65 – 135]	

Narrative Telling (Generation and Recall)

To test hypothesis one that all three groups of children (SLI, RLT, and TLD groups) would produce a comparable amount of main ideas in both the ERRNI Initial-Story Generation and Recall tasks, two separate one-way ANOVAs were conducted, with group as the between-subjects factor. For narrative generation, there was a significant group effect: $F(2, 88) = 3.64$, $p = .03$, $\eta_p^2 = .08$. Post hoc Tukey HSD analyses indicated that the children with SLI generated significantly fewer main ideas in their initial-story telling than the RLTs

(p = .03, Cohen's d = .70). The children with SLI provided fewer main ideas than the TLD group, with a medium effect size (Cohen's d = .61); however, the group difference was not significant at a .05 alpha level (p = .07). For narrative generation, the performance of the RLT and TLD groups was not significantly different (p = .97, Cohen's d = .05).

A medium group effect was also found for narrative recall: $F(2, 88) = 5.71$, $p = .005$, $\eta_p^2 = .11$. Post hoc analyses revealed that the children with SLI recalled significantly less story content after a delay than the RLT group, and there was a large effect size (p = .003, Cohen's d = 1.03). While the SLI group had a lower mean score than the TLD group, this difference was not statistically significant, but the effect size was medium to large (p = .08, Cohen's d = .70). The performance of the RLT group was similar to that of the TLD group on ERRNI Recall (p = .44, Cohen's d = .27). To investigate whether children with SLI do more poorly on recall simply because they provide less information when initially telling the story, a one-way analysis of covariance was performed with initial-story generation used as the covariate. The estimated marginal means (and standard error) for delayed recall after adjusting for initial-story generation are: SLI: 90.54 (1.87), RLT: 96.46 (1.44), TLD: 93.86 (1.56). After controlling for initial-story generation, the group effect on narrative recall showed a significance level of .05: $F(2, 87) = 3.09$, $p = .05$, $\eta_p^2 = .07$.

Comprehension

A one-way ANOVA was conducted, with group as the between-subjects factor, to explore group differences on the overall measure of comprehension. The results indicated a significant group effect: $F(2, 90) = 8.42$, $p < .001$, $\eta_p^2 = .16$. Post hoc Tukey HSD analyses indicated that the SLI group correctly answered significantly fewer comprehension questions than both the RLT group (p = .004) and the TLD group (p = .001), whereas no difference was found between the RLT and TLD groups (p = .67).

The two types of comprehension questions (literal and inferential) were examined in greater detail to investigate the second hypothesis that children with SLI would not be disadvantaged on literal comprehension questions, but would perform significantly poorer than both the TLD and RLT groups on inferencing questions. The mean scores, standard deviations, and range of scores for the literal and inferential comprehension questions are shown in Table 9. A one-way ANOVA was conducted on each type of comprehension question. For the literal questions, the analysis revealed no significant between-group differences: $F(2, 90) = .31$, $p = .73$, $\eta_p^2 = .01$. In contrast, a medium-to-large group effect was found for inferential questions: $F(2, 90) = 8.95$, $p < .001$, $\eta_p^2 = .17$. Post hoc Tukey HSD comparisons revealed that the children with SLI correctly answered significantly fewer inferential questions than both the RLT group ($p = .003$, Cohen's $d = .99$) and TLD group ($p < .001$, Cohen's $d = 1.08$), with large effect sizes, whereas no difference was found between the RLT and TLD groups ($p = .66$).

Table 9

Descriptive Statistics for ERRNI Inferential and Literal Comprehension

	SLI		RLT		TLD	
	M	*(SD)*	*M*	*(SD)*	*M*	*(SD)*
Comprehension	[Min – Max]		[Min – Max]		[Min – Max]	
Literal (max. score=6)	1.42	(1.25)	1.53	(1.06)	1.68	(1.42)
	[0 – 4]		[0 – 3]		[0 – 5]	
Inferential (max. score=12)	2.25	(2.29)	4.84	(3.12)	5.45	(3.08)
	[-1 – 7]		[-2 – 11]		[-1 – 11]	

Norbury and Bishop (2002) found performance of children with SLI and TLD to differ across different types of inferential questions. Therefore, exploratory analyses were conducted to investigate performance on the three types of inferential comprehension questions: gap-filling, emotional inferencing, and theory of mind. The mean raw scores with 95% confidence intervals for each group on each inferential question type are illustrated in Figure 5. Figure 5 demonstrates that children from each group achieved higher scores on the gap-filling questions than on the theory of mind or emotional inferencing comprehension questions.

Three one-way ANOVAs were conducted to assess group differences on the three types of inferential questions[1]. For gap-filling questions, the main effect for group was significant, $F(2, 90) = 4.18$, $p = .02$; $\eta_p^2 = .08$. Post hoc comparisons using the Tukey HSD test indicated one significant group difference; the SLI group performed significantly poorer than the RLT group ($p = .02$). The main effect for group was also significant for the questions tapping theory of mind, $F(2, 90) = 3.71$, $p = .03$, $\eta_p^2 = .08$, with the SLI group performing significantly poorer than the TLD group ($p = .02$). Lastly, for the questions that required children to infer the characters' emotional state, the main effect for group was significant, $F(2, 90) = 6.20$, $p = .003$, $\eta_p^2 = .12$, with a medium effect size. Post hoc Tukey HSD tests revealed that children with SLI had significantly greater difficulty inferring the emotions of characters than both the RLTs ($p = .04$) and children with TLD ($p = .002$).

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[1] Three separate ANOVAs were conducted, as opposed to a MANOVA, as the correlations between the scores of the three types of inferential questions were small to medium ($r = .28$ to $r = .33$).

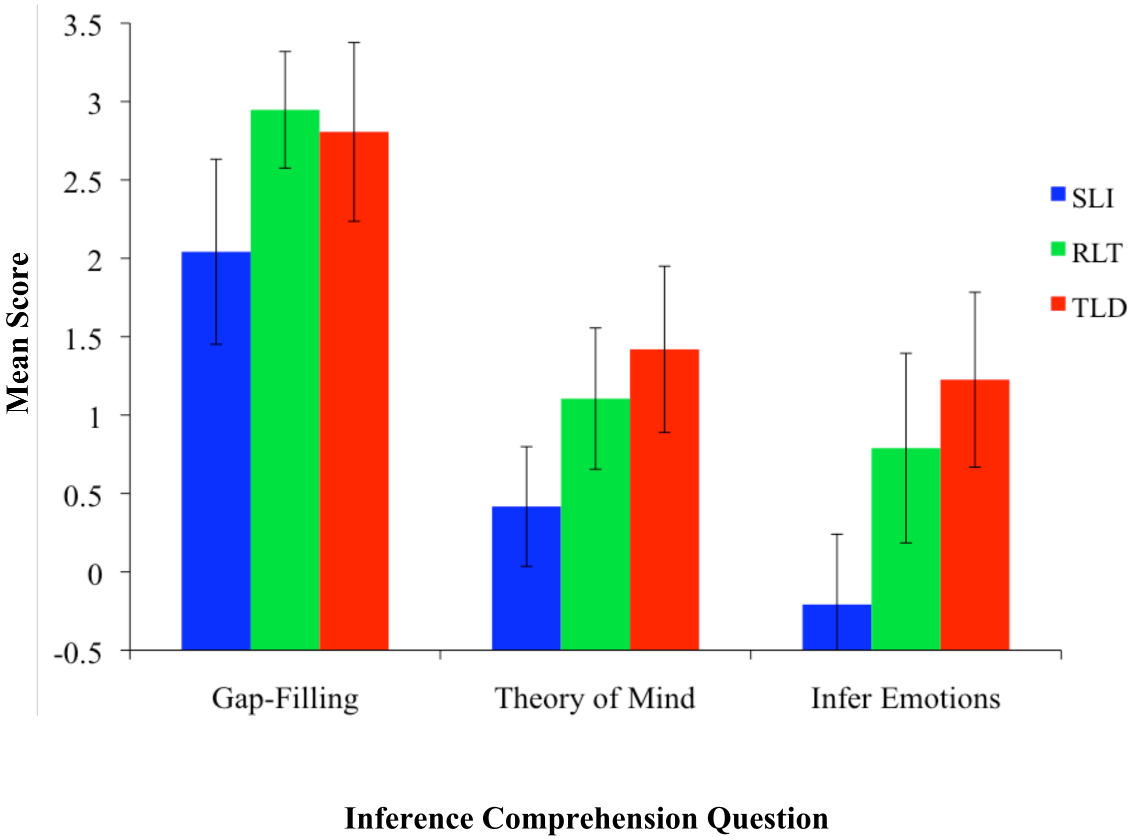

Figure 5. Mean scores and 95% confidence intervals of inferential comprehension question type by language group.

Further Analyses

As reported previously, the groups were not significantly different on nonverbal IQ as measured by the K-Bit Matrices subtest. However, given that nonverbal IQ could contribute to individual performances, exploratory analyses using ANCOVA were conducted to determine if the results reported above for ERRNI Initial-Story Generation, Recall and Comprehension held if K-Bit standard scores were included as a covariate in the analyses (See Table 10 for adjusted mean standard scores and standard error). After adjusting for nonverbal cognitive ability, the significant main effects of group remained for Initial-Story Generation, $F(2,87) = 3.25$, $p = .04$, $\eta_p^2 = .07$, Recall, $F(2,87) = 5.71$, $p < .01$, $\eta_p^2 = .12$, and Comprehension, $F(2,89) = 8.24$, $p = .001$, $\eta_p^2 = .16$, and the effect sizes were relatively stable.

The between-group differences cannot be attributed to individual children's performance on the K-Bit Matrices task.

Table 10

Adjusted Mean Standard Scores (and Standard Error) for ERRNI Initial-Story Generation, Recall and Comprehension

	SLI		RLT		TLD	
Measure	*M*	*(SE)*	*M*	*(SE)*	*M*	*(SE)*
Initial-Story Generation	93.75	(2.54)	101.22	(2.03)	101.28	(2.19)
Recall	88.66	(1.98)	97.29	(1.58)	94.26	(1.71)
Comprehension	85.46	(3.27)	97.93	(2.63)	102.70	(2.89)

Relationship among Measures of Comprehension and Narrative Telling

Pearson's product-moment correlations were performed to investigate the relationships amongst the measures of comprehension (literal and inferential) and narrative generation and recall for each group. There were no significant differences between the RLTs and children with TLD on any of the three narrative measures; this justified collapsing the two groups into one group (RLT+TLD), representing children with language scores within the normal range at age 4 years. The results are presented in Table 11.

Table 11

Pearson's r Correlations between the Measures of Narrative Generation, Recall and Literal and Inferential Comprehension for the SLI Group and the RLT+TLD Group

Measure	1	2	3	4
		SLI (n = 23)		
1. ERRNI Generation	-	-.20	-.10	-.13
2. ERRNI Recall		-	-.08	.14
3. Literal			-	-.15
4. Inferential				-
		RLT + TLD (n = 68)		
1. ERRNI Generation	-	.49**	.14	.43**
2. ERRNI Recall		-	.07	.33**
3. Literal			-	.21
4. Inferential				-

Note. * $p < .05$ two-tailed. ** $p < .01$ two-tailed.

As can be seen in Table 11, differences in correlations were found between the groups. Consistent with hypothesis three, for the RLT + TLD group, a greater amount of information generated in the ERRNI task was moderately associated with greater recall following a delay (r = .49) and better performance on the inferential comprehension questions (r = .43). In addition, for the RLT + TLD group, greater recall of information after a delay was moderately correlated with better performance on the inferential comprehension questions (r = .33). Inconsistent with hypothesis three, no correlation between measures of narrative generation, recall, and comprehension reached significance for the SLI group.[2]

Associations among Working Memory Measures and Narrative Scores

Pearson product-moment correlations were performed to test hypothesis four, that there would be significant associations between the working memory measures from Study One and the narrative measures from the current study. Again, as there were no significant differences between the RLTs and children with TLD on the working memory and narrative measures, these two groups were collapsed into one group, RLT + TLD. Table 12 shows the correlation coefficients for the SLI group and the RLT + TLD group.

[2] Controlling for gender had very little effect on the strength of the relationships between the narrative measures and there were no changes in the significance of correlations, so these correlations are not reported.

Table 12

Pearson's r Correlations between Working Memory and Narrative Measures for the SLI Group and the RLT+TLD Group

Measure	1	2	3	4	5	6	7	8
SLI (*n* = 20)								
1. EGenerat	-	-.17	-.06	-.26	-.28	-.03	-.22	-.47*
2. ERecall		-	.07	-.02	.21	-.13	.20	.43
3. ECompreh			-	.48*	.47*	.44	.50*	.49*
4. CNRep				-	.37	.43	.69**	.57**
5. BlockRecall					-	.59**	.18	.56*
6. PictureLoc						-	.17	.44
7. RecallSent							-	.46*
8. BDigRecall								-
RLT + TLD (*n* = 66)								
1. EGenerat	-	.49**	.44**	-.11	.11	.06	.29*	.03
2. ERecall		-	.33**	-.04	.03	-.13	.18	.04
3. ECompreh			-	.05	.00	-.02	.44**	-.01
4. CNRep				-	-.11	.06	.39**	.13
5. BlockRecall					-	.26*	-.03	.21
6. PictureLoc						-	.07	.15
7. RecallSent							-	.39**
8. BDigRecall								-

Note. * $p < .05$ two-tailed. ** $p < .01$ two-tailed.

Working Memory Measures: Phonological Loop: CNRep, The Children's Test of Nonword Repetition. Visuospatial sketchpad: BlockRecall, Block Recall; PictureLoc, Picture

Locations. Episodic buffer: RecallSent, Recalling Sentences. Central executive: BDigRecall, Backward Digit Recall.

Narrative Measures: EGenerat, ERRNI Initial-Story Generation; ERecall, ERRNI Recall; ECompreh, ERRNI Comprehension.

As can be seen in Table 12, differences in correlations were found between the two groups. For the RLT+TLD group, performance on the measure of the episodic buffer, recalling sentences, was significantly correlated with initial-story generation (r = .29) and comprehension (r = .44). Children's performance on the measure of the episodic buffer explained 8.4% and 19.4% of the variance in their story generation and performance on the comprehension questions, respectively. There were no further significant correlations between the narrative and working memory measures for the RLT+TLD group.

For the SLI group, initial-story generation was negatively correlated with the measure of the central executive, backward digit recall (r = -.47); that is, the better the children with SLI performed on the backward digit task the poorer they were at generating a narrative or visa versa. Backward digit recall was also moderately correlated with narrative recall (r = .43), with a p value of .056. Each working memory measure included had a medium to strong correlation with narrative comprehension. Performance on the measure of the phonological loop (CNRep; r = .48), visuospatial sketchpad (Block recall; r = .47), episodic buffer (Recalling Sentences; r = .50), and central executive (Backward Digit Recall; r = .49) was significantly correlated with narrative comprehension. However, the moderate correlation between comprehension and picture locations ($r = .44$) was not significant at the $p < .05$ level ($p = .051$).[3]

A linear regression was run to determine whether the working memory measures uniquely predicted a portion of the variance on the ERRNI Comprehension for children with SLI. The variables of CNRep, Block Recall, Recalling Sentences, and Backward Digit Recall were entered into the linear regression since they all correlated significantly with ERRNI Comprehension. These variables explained 41% of the variance; however, this result was not statistically significant, $R^2 = .41$ (Adjusted $R^2 = .26$), $F(4, 16) = 2.78$, $p = .06$. Study One found that backward digit recall was not a good discriminatory tool for the 5-year-old children; therefore, this variable was omitted from the model and the linear regression was rerun. This model (CNRep, Block Recall, and Recalling Sentences) explained a significant amount of variance in ERRNI comprehension: $R^2 = .39$ (Adjusted $R^2 = .30$), $F(3, 17) = 3.58$, $p = .04$. However, no variable made a unique contribution to the prediction of ERRNI Comprehension ($p > .05$).

To test hypothesis five, Pearson product-moment correlations were conducted with the verbal domain conditions of the dual-processing task from Study One and the ERRNI narrative measures. The results are presented in Table 13.

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[3] For the RLT+TLD group, controlling for gender had little effect on the strength of the correlations between working memory and narrative abilities and there was no change in significance levels. This was also the case for the SLI group, except for the partial correlation between backward digit recall and ERRNI generation ($r = -.42$), which was slightly weaker.

Table 13

Pearson's r Correlations between the Verbal Domain Conditions of the Dual-Processing Task and Narrative Measures for the SLI Group and the RLT+TLD Group

Measure	1	2	3	4	5	6
			SLI (*n* = 18)			
1. Generation	-	-.20	-.00	-.03	.00	-.10
2. Recall		-	-.13	.10	.21	.11
3. Comprehension			-	.11	.18	-.11
4.Vspan				-	.10	.42
5.VVspan					-	.22
6. VSspan						-
			RLT + TLD (*n* = 61)			
1. Generation	-	.51**	.43**	-.09	.01	-.08
2. Recall		-	.32*	-.19	.04	-.21
3. Comprehension			-	-.02	.23	.04
4.Vspan				-	.08	.32*
5.VVspan					-	.41**
6. VSspan						-

Note. * $p < .05$ two-tailed. ** $p < .01$ two-tailed.

Narrative measures: Generation, ERRNI Initial-Story Generation; Recall, ERRNI Recall; Comprehension, ERRNI Comprehension.

Verbal domain condition, dual-processing task: Vspan, No identification condition; VVspan, Colour naming condition; VSspan, Colour pointing condition.

Table 13 shows no significant correlations between the verbal domain conditions of the dual-processing task from Study One and the narrative measures for both groups.

Discussion

The aims of Study Two were to investigate the narrative and comprehension (literal and inferential) skills of three groups of children, children with SLI, RLTs, and children with TLD, and to explore the working memory mechanisms in relation to children's generation, recall, and comprehension of a self-initiated narrative.

The first hypothesis that all three groups of children would produce a similar number of main ideas when generating and recalling a narrative was partially supported. First, the narrative skills of children with SLI relative to typically developing children will be discussed, and this will be followed by a discussion of the narrative skills of RLTs, relative to children with SLI and typically developing children. The findings of this study will be discussed in the context of previous research.

Consistent with hypothesis one, based on the scores for main ideas provided for the ERRNI Fish Story, children with SLI were able to generate a story and then recall the story after a short delay as well as children with TLD. However, the effect sizes indicate that with a larger sample significant results might have been obtained. Nonetheless, these findings are in line with those of Dodwell and Bavin (2008) and Norbury and Bishop (2002; 2003) who found that children with SLI, varying in age from 6 to 10 years, provided a comparable amount of information in narrative generation and recall tasks relative to typically developing children. Norbury and Bishop (2003), for example, found no differences between children with SLI and typically developing children on global story structure or the total information provided when generating a narrative from a wordless picture book. Similarly, the children with SLI in the current study were able to extract the same amount of information from a picture sequence and form a representation of the story in memory. It is likely that this representation facilitated later recall (Bishop & Donlan, 2005). Bishop and Donlan (2005) proposed that the use of pictures facilitate better encoding of information, which allows for better recall, and this seems to be so for the three groups in the present study. When events can be encoded into a story an integrated representation is formed, and this is much more resistant to forgetting than a more fragmented series of details.

Bishop and Donlan (2005) found differing results for children with expressive-SLI relative to receptive-SLI on a narrative task. Whilst children with receptive-SLI provided fewer main story ideas when generating and recalling narratives relative to children with TLD, children with expressive-SLI did not. Given the small number of children with expressive- or receptive-SLI in the current study, nine and seven children, respectively, statistical analyses were not performed to explore group differences. For future research, it would be of benefit to compare different subgroups of SLI, relative to each other and to typically developing children.

As expected, when generating and recalling a narrative from pictures, RLTs provided a comparable amount of information as children with TLD. However, inconsistent with the first hypothesis, children with SLI conveyed significantly less information than the RLTs when generating and then recalling the narrative after a short delay. Controlling for nonverbal IQ, as measured by the K-Bit Matrices subtest, did not alter these results. Of note, when the amount of information provided in the initial narrative was controlled for, the groups no longer differed on the recall of sequences of events. This suggests that differences between the groups were related to their initial telling of the story.

Previous research has demonstrated that children with early expressive language delay at 20-34 months, but normal expressive language ability at 5;10 (RLTs), generated the same amount of information from a picture book as children with TLD and children with an expressive language disorder, that is, children identified at age 2 as late talkers and who continued to show deficits in expressive syntax and morphology (ELD; Paul, Hernandez, Taylor, & Johnson, 1996). So although both that study and the current study showed that RLTs were not impaired relative to typically developing children in terms of generating a narrative, and in the current study, RLTs were not impaired in remembering the narrative, children with SLI had difficulty encoding sequences of events compared to RLTs. Of note, in Paul et al.'s (1996) study, the classification of ELD was made when performance was below the 10^{th} percentile on productive syntax in spontaneous speech, as indexed by the Developmental Sentence Score but there was no measure of nonverbal ability, and therefore, it was not known if these children could be classified as SLI or not.

As narrative skills continue to develop beyond 8 years of age, differences in narrative recall and generation between the three groups may become more apparent in older children and adolescents. For example, while at age 5 years, children have the ability to understand and produce stories around a conflict, at 8 to 10 years children understand and produce more complex stories that include repeated attempts by the characters to achieve their goal (Montgomery, et al., 2009). There is a clear need to investigate the narrative skills of children with a history of late-talking in a longitudinal study.

Consistent with hypothesis two, children with SLI were not disadvantaged on the literal comprehension questions, but performed significantly poorer than both the typically developing children and RLTs on the inferencing comprehension questions. Controlling for nonverbal IQ did not alter these results. On the literal questions, all groups scored similarly with no group mean above two (of a possible six). Dodwell and Bavin (2008) reported similar findings using the same stimuli, finding no group mean above three, but with older children with SLI, aged 6;1 to 7;0 years. Correct responses to the literal questions (e.g., *On the next page, which animals were at the front of the pet shop?* or *On the next page, there is a telephone. What colour is it?*) relied upon the children's memory of the pictures in the storybook. The information requested was not salient aspects of the story (e.g., the colour of a telephone) and therefore, the children from all three groups had difficulty initially processing or retaining this information over a short period. For instance, 84% of the children with SLI, 68.6% of the RLTs, and 67.7% of the children with TLD failed to correctly answer the question, *Where did they eat their ice-creams*? A restricted range of scores on the literal comprehension questions may have affected the pattern of group differences. Future studies may wish to include literal questions based on more salient features of the story, as this might create a larger range of performance and allow for group differences to emerge if they truly were to exist.

In support of previous literature, children with SLI had difficulty with inferencing (Dodwell & Bavin, 2008; Norbury & Bishop, 2002), which interferes with the ability to form an integrated and coherent model of a wordless picture book. They had greater difficulty than the typically developing children and RLTs across the three types of inferencing: gap-filling, theory of mind, and inferring emotions. Of significance, none of the children with SLI correctly inferred the emotional state of the boy, whereas 6 RLTs (15.8%) and 7 children with TLD (22.6%) did. This may reflect problems attributing emotions to other people in SLI. Overall, these findings suggest that children with SLI have difficulty with the abstraction of information that is not explicitly presented in the picture book and the integration of this information with his/her own general knowledge. Despite an early delay of language, RLTs do not show deficits in this area.

Across groups, children appeared to have greater difficulty inferring the characters' mental or emotional states that cause action, relative to filling in gaps in the story. In contrast, the 6- to 10-year-old children in Norbury and Bishop's (2002) study found gap-filling inferences more difficult than text-connecting inferences. It is likely that the different types of inference questions used resulted in the different findings across studies. Children in the current study had difficulty taking the perspective of the characters and inferring mood, and this could be attributed to the young age of the children and the developmental nature of theory of mind. It is after the age of 4 years, when typically developing children begin to understand that different people can have different thoughts about the same situation and are able to infer one's mental state (Baron-Cohen, Leslie, & Frith, 1985; Smith, Cowie, & Blades, 2003; Wimmer & Perner, 1983).

Relationships among Measures of Comprehension and Narrative Telling

As expected, for the children with language abilities within the normal limits at age 4 years (RLTs and children with TLD), significant correlations were found among measures of narrative generation, recall, and comprehension. Children who included more of the main story ideas in their story generation, tended to have better recall of the narrative and better scores on the inferential comprehension questions. This lends support to the notion that as children tell stories, they are actively engaged in constructive processing that enables them to build an integrated and stable mental representation of the story so that they can recall it. This model not only facilitates their memory for the story, but also promotes better understanding of the story (Norbury & Bishop, 2002). The relationship between the number of main story ideas produced in telling and recalling stories adds confirmation to the view that good narrative recall is accounted for by good initial encoding. Of note, literal comprehension was not correlated with narrative generation or recall. As previously noted, unlike the inferential questions, the content of the literal comprehension questions were not salient features of the narrative and therefore, children would have easily overlooked these details or not considered them essential for the story. In the current study, there was an unequal gender distribution, with more female than male participants, particularly in the RLT group. However, controlling for gender had little effect on the strength of the correlations.

Contrary to expectations and the findings of Norbury and Bishop (2002), for the SLI group the correlational analysis did not show any significant associations between narrative generation, recall, or comprehension. Norbury and Bishop found children with SLI who had better comprehension tended to have better narrative recall. Differences in the age of the children, identification of SLI and the nature of the narrative tasks (e.g., types of comprehension questions) may account for the different results across studies. Overall, the lack of correlations in the SLI group suggests either that the variability in the group is too great at such a young age to detect patterns or that children with SLI use different procedures in constructing and recalling narratives.

Relationships between Measures of Working Memory and Narrative Ability

A strength of the study is the exploration of the relationships between working memory measures and higher order narrative skills. Consistent with hypothesis four, a number of working memory measures were significantly correlated with narrative scores. Different patterns of correlations were found between the children with SLI and children with language abilities within the normal limits at age 4 years. For the RLT + TLD group, the episodic buffer, as measured by recalling sentences, was associated with the children's generation and understanding of a narrative. This finding was not unexpected given that the role of the episodic buffer is to integrate information from the components of working memory and long-term memory into a single coherent complex structure (Baddeley, 2000). Generation of a narrative and understanding what it is about requires the child to store a number of representations in memory while integrating new incoming material as well as information from long-term memory (Botting & Adams, 2005). The phonological loop, visuospatial sketchpad, and central executive played no significant part in explaining the children's narrative scores. Montgomery, Polunenko, and Marinellie (2009) also found that a phonological loop measure (digit span) did not account for any variance in the narrative comprehension of typically developing children. The researchers argued that the construction, recall, and understanding of a narrative involves the processing, storage, re-activation, and integration of a large amount of verbal information that exceeds the limits of the phonological loop capacity.

Inconsistent with hypothesis five and Montgomery et al.'s (2009) study, which found that performance on a dual-processing task correlated significantly to the comprehension scores of children with TLD, in the current study performance on the verbal domain conditions of the dual-processing task did not correlate to narrative comprehension for the RLT + TLD group. The discrepancy in findings may relate to a number of factors: differences in subject inclusion criteria, the age of children tested (children were aged 6 to 11 years in their study), the types of materials used to elicit the narratives or the nature of the dual-processing tasks.

For children with SLI, measures of the phonological loop, visuospatial sketchpad, episodic buffer, and central executive all correlated with narrative comprehension. That is, children who performed well on these memory tasks also performed well on the narrative comprehension questions. Superior performance on a visuospatial recall task (block recall) was associated with a better performance on the comprehension questions. Some of the comprehension questions focused upon the features of the pictures (such as, which animals were at the front of the pet shop), which are likely to tap into the children's visuospatial memory of the pictures. Furthermore, a model including the CNRep, block recall, and recalling sentences was predictive of ERRNI comprehension for children with SLI. Overall, the different correlations between children with impaired language abilities at 4 years, relative to those with normal language skills, suggest that different processes may be contributing to narrative performance.

Conclusion

The study showed that children with SLI, aged 5 years, were unimpaired in the generation and recall of narratives, relative to children with TLD. However, the medium-to-large effect sizes indicate that with a larger sample size significant results might have been obtained. Relative to RLTs, children with SLI conveyed less information when generating and recalling the narrative after a short delay. The RLTs in the present study displayed age-appropriate narrative abilities, in that they did not differ significantly from children with TLD, despite early lag in language development. Therefore, it is certainly possible for children to get a late start at talking but to catch up to the proficiency level of their peers. The current study also demonstrated that integrating information was problematic for children with SLI, as shown by the low inferencing scores relative to both typically developing children and RLTs. The study also showed, as reported in previous research, that working memory is implicated in the construction and comprehension of narratives.

CHAPTER 7

STUDY THREE

Introduction

Studies using narratives to investigate language skills provide an opportunity to identify discourse problems that may not be identified with standardised language assessments. The results from Study Two highlighted the benefit of using narratives to differentiate between the higher order language skills of typically developing children and late-talking children who demonstrate language abilities within normal limits in preschool years, and those of children who continue to demonstrate impaired language abilities. Study Two documented that, as a group, the 5-year-old children with SLI demonstrated impaired narrative generation and recall relative to RLTs, as well as deficits in understanding narratives relative to both RLTs and children with TLD, which appears to be associated with their limited working memory. There is now general awareness that the investigation of language in a narrative discourse provides rich information not only about linguistic skills, but also about the child's cognitive and social knowledge (Bamberg & Damrad-Frye, 1991; Tager-Flusberg, 1995). For example, in order to provide a rich narrative that maintains the listeners' attention whilst conveying the main elements of the story, the child will go beyond what is directly observable in the pictures and provide evaluative devices (Tager-Flusberg, 1995).

As discussed in Chapter 4, studies of narratives and their development have focused on different features of the stories. One approach has been to explore the child's understanding of the event structure of narratives, whilst another has been to investigate specific linguistic features, including referential devices (Reilly, Bates, & Marchman, 1998).

Aims and Hypotheses

The present study aimed to contribute to the growing body of knowledge regarding the narrative abilities of children with SLI and RLTs. The primary goal of the study was to expand upon previous research by using a set of pictures bound into a book form to elicit narratives from children with SLI, and to compare their performance to that of RLTs and children with TLD in order to explore group similarities and differences in narrative performance. The generated narratives were coded on a range of measures tapping the following characteristics: global plot structure, narrative length and syntactic complexity, evaluative devices, and referential devices. Another goal was to investigate the relationships among these different aspects. To measure length, word count was not judged to be a reliable measure since there were repetitions and false starts. Rather number of clauses was used, measured by the number of verbs. Six hypotheses were formulated:

i. Based on the findings of Botting (2002) and Norbury and Bishop (2003), group differences were not expected between children with SLI and typically developing children with respect to global plot structure.

ii. Based on the research of Paul and colleagues (1996), it was predicted that the RLTs would perform significantly poorer than children with TLD on the measure of global plot structure, but similar to children with SLI.

iii. No group difference was predicted between children with SLI and typically developing children on the total number of clauses.

iv. Because problems with grammar are associated with SLI, it was predicted that the children with SLI would produce less syntactically complex stories than the typically developing children, indexed by the number of subordinate clauses and the proportion of subordinate clauses to total number of clauses. The RLTs were expected to produce a comparable number and proportion of subordinate clauses relative to children with TLD.

v. As previously found (Norbury & Bishop, 2003), it was expected that the SLI and TLD groups would not differ with respect to their overall use of evaluative devices and it was expected that the RLTs would perform similarly to the other two groups.

vi. Based on research with children with typical development, it was predicted that children would perform similarly in introducing and maintaining reference to story characters, because at age 5 years cohesion strategies are not well developed.

Method

Participants

The participants in this study were the same children who participated in Studies One and Two. As per Study One, 24 children with SLI, 39 RLTs, and 32 children with TLD participated in the current study. See Chapter 5 for details of screening and classification of the language groups.

Materials

The Fish Story from the ERRNI (Bishop, 2004), from Study Two, was used (See Chapter 6 for details). During the generation of each narrative, responses were audio taped for transcription and analysis. The narratives were analysed by hand for global plot structure, length, syntactic complexity, evaluative device, and cohesion as indicated by the introduction and maintenance of reference as discussed below.

Analyses

Global Plot Structure

The extent to which children organised their narratives around a global plot structure was assessed by identifying the presence of each core story component, as listed in Table 14. Global plot structure provided a measure of the extent to which children could infer the causal relationships between the pictures rather than simply describing the pictures in the book as a series of unrelated events (Berman & Katzenberg, 1998). Children received one point for mentioning each component in their narrative. Thus, children could receive a maximum of 12 points for global plot structure.

Length of Narrative

The number of clauses provided a measure of length (Botting, 2002). This was calculated by counting the total number of verbs (tokens) used per narrative. The diversity of verbs used, that is, the number of different types of verbs (types) was also calculated. Based on the work of Norbury and Bishop (2003), verbs were divided into three categories: action verbs, mental state verbs, and "other" verbs. Action verbs included verbs such as *feed*, *walk*, *go*, and *ring*. Mental state verbs included verbs of communication (e.g., *say*, *ask*), belief/desire (e.g., *want*, *think*), general cognitive (e.g., *know*, *decide*), and experience (e.g., *hear*, *see*), all of which required some insight into the character's perspective. The other category included verbs of possession (e.g., *own*), existence (e.g., *is*), and continuity (e.g., *stop*, *finished*).

Table 14

Twelve Core Story Components of Global Plot Structure

Core Story Components	
Setting	The boy is feeding the fish
Initiating event	Mother gives the boy money
Actions aimed at meeting the goal	The boy is walking
	The pet-shop
	And buys a fish
	The boy meets friends
	Switch: girl swaps objects in the bags
	Discovery: boy finds he has the doll in the bag, not the fish
	Mother rings girls to find the fish
	Friends come over to the boy's house
Resolution	Exchange bags: boy has his fish and/or girl gets her doll back
Overall conclusion	The boy now has two fish

Syntactic Complexity

The total number of subordinate clauses per narrative was calculated to assess the children's syntactic knowledge and use. Based on the work of Gummersall and Strong (1990), the types of subordinate clauses were: relative clause, adverbial clause, and complement clause, as listed and described in Table 15. Examples are taken from the narratives produced. The number of each type was added to determine the total number of subordinate clauses per narrative generated. The proportion of subordinate clauses to the total number of clauses provided a measure of syntactic complexity: Subordinate Clause Ratio (SCR).

Table 15

Types of Subordinate Clauses

Type	Explanation and Example
Relative clause	Modifies a noun phrase. Example: *The person who owned the shop gave that fish to him*
Adverbial clause (Including temporal, causative, and resultative clauses)	Modifies verbs. Example of temporal clause: *When he got to the fish shop, he ……*
Complement clause	Functions as argument of sentence
Infinitive clause	*The boy left to go for a walk*
That clause	*The boy didn't know that it was a doll*
-*ing* clause	*He liked eating ice cream*

Narrative Evaluation

The narratives were analysed in terms of the total number of evaluative devices used and evaluative type (that is, the number of different types of evaluative devices used), based on the five-category system put forward by Bamberg and Damrad-Frye (1991), as discussed in Chapter 4. This coding system for evaluative devices was chosen because it has been used extensively in researching narratives by typically developing children, and has been used to analyse narratives of late talkers (Manhardt & Rescorla, 2002) and children with SLI (Norbury & Bishop, 2003). The five types of evaluative devices were: (a) Frames of mind, including emotional states (e.g., *happy*, *sad*) and mental states (e.g., *want*, *decided*); (b)

Character direct (e.g., *Can I have another fish?*) or indirect speech (e.g., *The boy asked the lady to give him some fish food*); (c) Hedges (e.g., *I <u>think</u> he got a fish* or *I <u>might</u> go and get another fish*); (d) Negative comments (e.g., *didn't* or *he's <u>not</u> waiting in line*); (e) Causal connectors (use of terms such as *because*, which provide information about the relationships between the narrative events; e.g., *The boy was angry <u>because the girl took his fish</u>*).

Cohesion

Based on the extensive literature on the introduction and maintenance of reference (e.g., Karmiloff-Smith, 1985), two measures of referential devices were used. The way in which the main character (the boy) in the story was introduced was coded. On first mention, one would expect a mature storyteller to introduce the character with an indefinite article (e.g., *a boy*). Other means, which assume the identity of the character, include using a definite noun (e.g., *the boy* or *this boy*) or a pronoun (e.g., *he*). Maintenance of character reference was also coded. Pronouns are more appropriate for maintaining reference than repeating a nominal phrase such as *the boy* (Karmiloff-Smith, 1985; Van Der Lely, 1997). In some contexts, a zero anaphora is also appropriate for maintaining reference, for example, *He bought an ice-cream and _ ate it*. It can be described as "referring back" to an expression that provides the information necessary for interpreting the gap. Therefore, the number of nominals, pronouns (e.g., *he/him*), zero anaphors, and possessive expressions (e.g., *his*) used to maintain references were counted. Plural referents (e.g., *they*) and ambiguous referents were excluded. For example, if the boy was included in the third-person pronoun, *they*, as when he was performing an action with the girls in the picture, this was not counted.

Inter-rater reliability was conducted by another researcher, naïve to the purposes of this study, on a sample of 12 cases (12.6%), with three cases randomly selected from each group. For the variables global plot structure, sum of evaluative devices, verb tokens, and verb types, the Kappa Measure of Agreement values varied from .80 to .90. According to

Peat (2001, p. 228), these values represent a very good agreement. All differences in scoring were reviewed and resolved by both scorers.

Results

For variables that met the assumptions for parametric tests, one-way ANOVAs were used with Tukey HSD tests for post-hoc comparisons. Effect size was reported in terms of the amount of variance explained, η_p^2. As indicated in Studies One and Two, .01 is a small effect, .09 a medium effect, and .25 a large effect (Cohen, 1988). Otherwise frequencies were analysed using the nonparametric technique of Chi-square test for independence[1]. Other data are presented qualitatively. Data were not available for one child with SLI, two RLTs, and one typically developing child due to noncompliance to the test procedure or failure of recording equipment.

Results are presented in the following order: Firstly the results relating to the global plot structure of the narratives are presented followed by the results relating to the length and syntactic complexity of the narratives and the use of evaluative devices. These results are followed by a correlation analysis (with the size of correlations interpreted as in Studies One and Two) and the results from the analyses on cohesion.

Table 16 presents the means, medians, standard deviations, and ranges for the measure of global plot structure, length, and syntactic complexity.

[1] Based on the work of Camilli and Hopkins (1978, p. 166), the Yates' correction for continuity was not applied as "its use would result in an unnecessary loss of power", that is, a tendency not to reject the null hypothesis when in fact it is false.

Table 16

Descriptive Statistics for Global Plot Structure, Total Verbs Used, Diversity of Verbs, Number of Subordinate Clauses, and Subordinate Clause Ratio (SCR) for each Group

	SLI			RLT			TLD		
	M	*(SD)*	*Mdn*	*M*	*(SD)*	*Mdn*	*M*	*(SD)*	*Mdn*
Measure	[Min – Max]			[Min – Max]			[Min – Max]		
Global structure	3.87	(1.84)	4.00	4.81	(1.91)	5.00	4.74	(2.14)	4.00
	[0 – 9]			[1 – 10]			[1 – 9]		
Verb tokens	21.04	(13.27)	17.00	21.32	(5.71)	21.00	20.10	(6.87)	19.00
	[0 – 54]			[11 – 38]			[7 – 36]		
Verb types	10.69	(5.09)	10.00	12.16	(2.89)	12.00	12.22	(3.69)	11.00
	[0 – 22]			[6 – 21]			[5 – 24]		
Subordinate	1.43	(1.67)	1.00	2.30	(1.78)	2.00	2.32	(2.57)	1.00
Clauses	[0 – 5]			[0 – 6]			[0 – 10]		
SCR	0.06	(0.06)	0.06	0.10	(0.07)	0.09	0.10	(0.09)	0.08
	[.00 - .22]			[.00 - .24]			[.00 - .29]		

Global Plot Structure

A univariate ANOVA was used to test hypotheses one and two, that the SLI group would achieve a similar global plot structure score to the RLT and TLD groups, but that the RLT group would perform significantly poorer than the TLD group. Inspection of the means[2] suggest that the SLI group provided fewer main components of the story than both the TLD

[2] There was one upper bound outlier in both the SLI and RLT groups. Changing these values to less extreme values made no change to the findings; therefore these cases were retained.

and RLT groups; however, there were no significant group differences, $F(2,88) = 1.83$, $p = .17$, $\eta_p^2 = .04$.

Inspection of the individual components that make up the global plot structure measure revealed that the majority of children from each group mentioned the setting of the narrative (SLI: 65.2%, RLT: 78.4%, TLD: 80.6%) and two salient components: the boy walking somewhere (SLI: 73.9%, RLT: 86.5%, TLD: 77.4%) and the boy buying a fish (SLI: 78.3%, RLT: 75.7%, TLD: 83.9%). In contrast, no child with SLI, one RLT, and two typically developing children identified the switching of the objects in the bag. Interestingly, these children were not the children who achieved the highest scores on global plot structure; their scores ranged from four to six. Additionally, few children mentioned the mother ringing the girls in an attempt to find the boy's fish (two children with SLI, five RLTs, and five children with TLD). Similarly, few children provided the resolution of the children exchanging the objects in their bags (two children with SLI, five RLTs, and five children with TLD). These components required the children to infer the causal relationships between the pictures rather than simply describing the pictures as a series of unrelated events. Lastly, only about one quarter of the children mentioned the initiating event of the mother giving the boy money: SLI: 21.7%, RLT: 24.3%, TLD: 25.8%. Many children from each group were observed to have difficulty identifying the item that the mother was giving to the boy; for example, one child stated, *Then the mother gave him a carved bird* (ID 1220, TLD) and another stated, *...she gave him more fish food* (ID 1011, RLT).

To determine whether the children with TLD or RLTs were more likely to have higher global plot structure scores than children with SLI and whether the TLD and RLT groups differed on this measure, a median split was used to dichotomise children into either > 4 or ≤ 4 on global plot structure. Three separate Chi-square tests of independence were conducted on these frequency data; one compared the SLI and RLT groups, one compared the SLI group with the TLD group and another compared the RLT and TLD groups. See Table 17 for the frequency of children in each group who achieved equal to or below the median score or above the median score for global plot structure. Despite a greater number of children with TLD achieving higher global plot structure scores, no significant difference was found between the SLI and TLD groups, $\chi^2(1, n = 54) = 1.76, p = .18$. Similarly, no significant difference was found between the RLT and TLD groups, $\chi^2(1, n = 68) = 0.83, p = .36$. In contrast, the RLTs were significantly more likely than the children with SLI to have higher global structure scores, $\chi^2(1, n = 60) = 4.78, p = .03$.

Table 17

Frequency of Children from each Group achieving Higher than and Lower or Equal to the Median Score for Global Plot Structure

	SLI (n = 23)	RLT (n = 37)	TLD (n = 31)
Global Structure			
≤ 4	16	15	16
> 4	7	22	15

Length and Syntactic Complexity of Narrative

Syntactic complexity was measured by the number of verbs, diversity of verbs, number of subordinate clauses, and the ratio of subordinate clauses to main clauses used in each narrative.

Verb tokens and types. Consistent with hypothesis three, the mean number of clauses[3], based on the number of verbs, was similar across each language group. A one-way ANOVA confirmed no significant group differences, $F(2, 88) = 0.18$, $p = .83$, $\eta_p^2 = .004$. It should be noted that there was a lot of variability in the SLI group, demonstrated by the large standard deviation of 13.27. Of note, three children with SLI produced exceptionally long narratives of 42 or more clauses.

The total number of different types of verbs used in the narratives was also examined and a one-way ANOVA revealed that the three groups produced a similar diversity of verbs, $F(2, 88) = 1.32$, $p = .27$, $\eta_p^2 = .03$.

To determine whether the children with TLD or RLTs were more likely to use a greater number as well as a greater diversity of verbs when generating a narrative than children with SLI, and whether the TLD and RLT groups significantly differed on these measures, Chi-square tests of independence were performed. The frequency of use for verb tokens and verb types was analysed using a median split to dichotomise children. For verb tokens, data were divided into ≥ 19 and < 19 verbs and for verb types, data were divided into ≥ 11 and < 11 (see Table 18).

[3] Due to the violation of the assumption of normality, the value of one extreme upper bound outlier in the TLD group was adjusted to the next highest score in the distribution plus one (Tabachnick & Fidell, 2007, p. 77). This variable subsequently met the assumption of normality.

Table 18

Frequency of Children from each Group achieving Lower than or Higher or Equal to the Median Score for Verb Token and Verb Type

	SLI (n = 23)	RLT (n = 37)	TLD (n = 31)
Verb Token			
< 19	15	14	15
≥ 19	8	23	16
Verb Type			
< 11	12	10	9
≥ 11	11	27	22

The analyses indicated that the RLTs were significantly more likely than the children with SLI to produce a greater number of verbs [$\chi^2(1, n = 60) = 4.26, p = .04$], as well as a greater number of different verbs [$\chi^2(1, n = 60) = 3.86, p < .05$] in their narratives. In contrast, no significant differences for verb token or type were found at the .05 significance level between the SLI and TLD groups [Verb Token: $\chi^2(1, n = 54) = 1.51, p = .22$, Verb Type: $\chi^2(1, n = 54) = 2.97, p = .08$] or the RLT and TLD groups [Verb Token: $\chi^2(1, n = 68) = 0.77, p = .38$, Verb Type: $\chi^2(1, n = 68) = 0.03, p = .85$].

Consistent with the work of Norbury and Bishop (2003), Table 19 demonstrates that the majority of verbs used by children from each group were action verbs, which accounted for over 70% of all verbs used across the groups. The proportion of verbs that expressed a mental state was much less, with a number of children from each group not using any mental state verbs in their narratives.

Table 19

Number (and Proportion) of Action Verbs, Mental State Verbs and Other Verbs used by each Group of Children

	SLI (n = 23)	RLT (n = 37)	TLD (n = 31)
Action verbs	191 (77.6%)	334 (74.2%)	302 (79.7%)
Mental State verbs	26 (10.6%)	66 (14.7%)	43 (11.3%)
Other verbs	29 (11.8%)	50 (11.1%)	34 (9.0%)
Total verbs	246	450	379

Subordinate clauses. Table 16 reports the mean number of subordinate clauses produced by each group of children. Inspection of the means revealed that the SLI group produced fewer subordinate clauses than both the RLT and TLD groups; however, a one-way ANOVA revealed no significant differences between groups, $F(2, 88) = 1.54$, $p = .22$, $\eta_p^2 = .03$[4]. To investigate the association between language group and frequency of use of subordinate clauses, three separate Chi-square tests of independence were performed; one compared the SLI group to the RLT group, one compared the SLI group to the TLD group, and another compared the RLT and TLD groups. Frequency was divided using a median split to dichotomise participants into either no use (< 1) or users (≥ 1) of subordinate clauses (See Table 20). The only significant group difference was found between the SLI and RLT groups [$\chi^2(1, n = 60) = 3.97$, $p < .05$], with the children in the RLT group more likely to use subordinate clauses in their narratives than children in the SLI group [TLD and SLI group:

[4] Due to the violation of the assumption of normality, the value of two upper bound outliers in the SLI group was moved to the next highest possible score plus one (Tabachnick & Fidell, 2007). This variable subsequently met the assumption of normality.

$\chi^2(1, n = 54) = 0.07, p = .78$]. No significant difference was found at the .05 alpha level between the RLT and TLD groups, $\chi^2(1, n = 68) = 3.34, p = .07$.

Table 20

Number of Children using Subordinate Clauses in each Group

	SLI (n = 23)	RLT (n = 37)	TLD (n = 31)
Subordinate Clause			
No use	9	6	11
Use	14	31	20

Inspection of the different types of subordinate clauses used in the narratives revealed that over half of the RLTs and typically developing children used at least one complement clause, while less than half of the children with SLI did so. As can be seen from Table 21, a greater number of children from each group used complement clauses, relative to adverbial or relative clauses. For example, few children produced relative clauses: one child with SLI, seven RLTs, and six typically developing children. Furthermore, for each type of subordinate clause, there were fewer children with SLI producing them compared with the RLTs and children with TLD.

Table 21

Number of Children from each Group using the Different Types of Subordinate Clauses

Clause Type	SLI (*n* = 23)	RLT (*n* = 37)	TLD (*n* = 31)
Adverbial Clause	3	13	10
Relative Clause	1	7	6
Complement Clause	14	27	20

Subordinate Clause Ratio. Table 16 reports the descriptive statistics for the measure reflecting the syntactic complexity of the narratives. This measure represents the ratio of the number of subordinate clauses to the total number of clauses in each narrative. As shown by the means, for the RLT and TLD groups, only 10% of the sentences were complex sentences and for the SLI this percentage was smaller, only 6%.

Evaluative Devices

Given that few evaluative devices were used by some of the children, the frequency of each type of evaluative device was collapsed to provide a sum of evaluative devices score[5]. Means, standard deviations, and ranges for the sum of evaluative devices, as well as the diversity of evaluative devices used (types) are presented in Table 22.

[5] Due to the violation of the assumption of normality, the values of one upper bound outlier in both the SLI and RLT groups and two in the TLD group were moved to the next highest possible score plus one (Tabachnick & Fidell, 2007). This variable subsequently met the assumption of normality.

Table 22

Descriptive Statistics of the Sum of Evaluative Devices and Evaluative Types for the SLI, RLT, and TLD Groups

	SLI		RLT		TLD	
	M	*(SD)*	*M*	*(SD)*	*M*	*(SD)*
Measure	[Min – Max]		[Min – Max]		[Min – Max]	
Sum of evaluative devices	2.43	(2.52)	3.05	(2.16)	1.81	(1.64)
	[0 - 9]		[0 - 8]		[0 - 5]	
Evaluative types	1.35	(1.07)	1.84	(1.19)	1.35	(1.30)
	[0 -3]		[0 - 4]		[0 – 5]	

To test hypothesis five, that the SLI, RLT, and TLD groups would not differ with respect to their overall use of evaluative devices, a one-way ANOVA was performed. In line with the findings of Norbury and Bishop (2003), groups did not differ significantly at the .05 alpha level on the total number of evaluative devices included in their narratives; the effect size was small-to-medium: $F(2,88) = 2.98$, $p = .06$, $\eta_p^2 = .06$. Even though there were no group differences in the frequency of use of evaluative devices, there could be differences in the diversity of evaluative devices used. To explore this possibility, a second one-way ANOVA was conducted to test whether the groups differed on the range of the different evaluative devices used, with the maximum devices used being five. Again the analysis revealed no significant between-group differences, $F(2,88) = 1.79$, $p =.17$, $\eta_p^2 = .04$. Inspection of the data revealed that three children in the RLT group and two children in the TLD groups used more than three different evaluative devices when generating a narrative, whilst no child in the SLI group used more than three different evaluative devices.

The use of the evaluative devices was investigated further, as shown in Tables 23 and 24. Table 23 shows the number of children in each group using each evaluative device, while Table 24 shows the number of examples of each evaluative device in each group.

Table 23

Number (Percentage) of Children in each Group using each Evaluative Device

	SLI (*n* = 23)	RLT (*n* = 37)	TLD (*n* = 31)
Frame of mind	6 (26.1%)	17 (45.9%)	13 (41.9%)
Character speech	10 (43.5%)	20 (54.0%)	8 (25.8%)
Hedges	1 (4.3%)	2 (5.4%)	3 (9.7%)
Negative comments	6 (26.1%)	10 (27.0%)	6 (19.3%)
Causal connectors	8 (34.8%)	19 (51.3%)	12 (38.7%)

Table 24

Total Number of each Type of Evaluative Device used by each Group

	SLI (*n* = 23)	RLT (*n* = 37)	TLD (*n* = 31)
Frame of mind	10	21	20
Character speech	25	41	27
Hedges	1	13	6
Negative comments	10	12	8
Causal connectors	12	32	20

As can be seen in Tables 23 and 24, across groups, children used more character speech in their narratives than any other evaluative device. Of interest, 20 RLTs used character speech in their narratives, compared to 10 and eight children in the SLI and TLD group, respectively. The second most frequently used evaluative device was causal connectors, suggesting that the children were able to integrate information in the story or explain the emotions and behaviours of the characters. For references to frame of mind, less than 50% of children in each group used this device; just over 40% of children in the RLT and TLD used the evaluative device, as compared to 26.1% of the children with SLI. The two least frequently used devices were negative comments and casual hedges. For hedges, there were only one and six examples for the SLI and TLD groups, respectively.

Correlational Analyses

Correlational analyses were conducted to examine how length (indexed by the number of verbs used), verb types, use of evaluative devices, and features of syntactic complexity relate to global plot structure (see Table 25). For each group, the top half of Table 25 shows the Pearson product-moment correlation coefficients from the bivariate correlation and the bottom half of the table shows the coefficients from the partial correlation controlling for the effects of narrative length, indexed by total verbs used.

Table 25

Pearson's r Correlations between Global Plot Structure, Verb Tokens and Types, Subordinate Clauses, Subordinate Clause Ratio and Evaluation for each Group (Partial Correlations controlling for Length in Italics)

Measure	1	2	3	4	5	6
SLI (n = 23)						
1. Global Structure	-	.54**	.62**	.37	.24	.41*
2. Verb Tokens	-	-	.90**	.53**	.23	.68**
3. Verb Types	*.38*	-	-	.40	.16	.54**
4. Subordinate Clause	*.12*	-	*-.21*	-	.85**	.27
5. SCR	*.14*	-	*-.11*	*.88***	-	.13
6. Evaluative Device	*.07*	-	*-.24*	*-.15*	*-.04*	-
RLT (n = 37)						
1. Global Structure	-	.32	.35*	.37*	.33*	.41*
2. Verb Tokens	-	-	.75**	.61**	.38*	.41*
3. Verb Types	*.17*	-	-	.67**	.51**	.43**
4. Subordinate Clause	*.23*	-	*.41**	-	.95**	.60**
5. SCR	*.23*	-	*.37**	*.98***	-	.59**
6. Evaluative Device	*.32*	-	*.20*	*.49***	*.51***	-
TLD (n = 31)						
1. Global Structure	-	.57**	.67**	.38*	.36*	.32
2. Verb Tokens	-	-	.76**	.80**	.64**	.60**
3. Verb Types	*.45**	-	-	.51**	.38*	.53**
4. Subordinate Clause	*-.14*	-	*-.24*	-	.94**	.61**
5. SCR	*-.01*	-	*-.21*	*.93***	-	.53**
6. Evaluative Device	*-.04*	-	*.14*	*.27*	*.23*	-

Note. SCR = Subordinate Clause Ratio.

* $p < .05$ two tailed. ** $p < .01$ two-tailed.

Results of the bivariate correlations revealed that for the TLD group, all variables were significantly correlated, except for global plot structure and evaluative devices. Similarly, for the RLT group, with the exception of global plot structure and verb tokens all variables were significantly correlated; this medium size correlation failed to reach significance. However, for the SLI group, while global plot structure correlated with verb tokens, verb types, and evaluative devices, it did not correlate with subordinate clauses or subordinate clause ratio. Unlike the correlations found for the TLD and RLT groups, evaluative devices did not significantly correlate with subordinate clauses or subordinate clause ratio. There was, however, a large correlation between verb tokens and subordinate clauses, and evaluative devices was significantly correlated with verb tokens and verb types.

The correlations discussed above show that children who produced longer narratives, indexed by the total number of clauses, or used a greater diversity of verbs had better global plot structure scores. In addition, the medium correlations between global plot structure and subordinate clauses suggest that the more core story components provided, the greater the syntactic complexity of the narratives. As expected, the number of subordinate clauses for each group was significantly related to verb tokens; with more clauses, it is likely that a higher proportion will be subordinate.

Partial correlations were conducted because with longer narratives it was more likely that more core story components, verbs types, complex sentences, and evaluative devices were included. Controlling for length had a large effect on the strength of most of the relationships discussed above (See lower triangles in Table 25). For the SLI and TLD groups, controlling for length led to many of the associations being no longer statistically significant. As expected, for both groups, subordinate clause continued to be correlated with subordinate clause ratio. For the TLD group only, the correlation between global plot structure and verb types also remained significant. That is, the more core story components included in the narratives, the greater diversity of verbs used. For the RLT group, global plot structure did not correlate significantly with any variable; however, the measures of syntactic complexity, subordinate clause, and subordinate clause ratio, were still correlated significantly with verb types as well as evaluative devices.

Cohesion: Introduction and Maintenance of Referent

The percentages of children who used a pronoun, an indefinite noun (e.g., *a boy*) or a definite noun (e.g., *the boy*) to introduce the main character in the story were calculated. Table 26 shows the percentage of children in each group using the various referential devices to introduce the main character. In introducing the boy, the large majority of children from each group used a definite noun phrase or pronoun, indicating that they assumed prior knowledge of the listener. Approximately 50% of children from each group used definite noun phrases to introduce the main character. Only about 10-15% of the children in each group used an indefinite noun and this would be considered the more mature way of introducing a main character.

Table 26

Percentages of Children using Different Referential Devices to Introduce the Boy

Reference to boy	SLI (*n* = 19)	RLT (*n* = 37)	TLD (*n* = 31)
Definite NP	52.6	54.0	45.2
Indefinite NP	15.8	13.5	9.7
Pronoun	31.6	27.0	38.7

Note. Four children with SLI, two RLTs and two children with TLD did not make reference to the main character in their narratives; therefore these children were not included in the calculations.

All subsequent references to the boy throughout the story were counted. The mean numbers of maintenance references for each group are shown in Table 27.

Table 27

Mean Number (and Standard Deviation) of Subsequent References to the Main Character by Type and by Group

	SLI (*n* = 23)		RLT (*n* = 37)		TLD (*n* = 31)	
Reference to boy	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*
Indefinite NP	0.13	(0.46)	0.54	(2.19)	0.29	(1.44)
Definite NP	0.91	(1.56)	2.84	(3.90)	1.58	(2.36)
Pronoun	6.78	(6.36)	7.32	(5.47)	7.00	(5.81)
Zero Anaphora	0.09	(0.29)	0.73	(1.39)	0.35	(0.71)
Possessive expression	0.96	(1.11)	2.32	(2.44)	2.77	(2.73)

As shown in Table 27, when maintaining reference to the main character, children in all groups used pronouns more frequently than the other possible forms. The group means revealed that indefinite noun phrases and zero anaphora were the two forms least used by each group. Furthermore, the children with TLD and RLTs tended to use more definite noun phrases, zero anaphora, and possessive expressions than children with SLI.

Discussion

The aim of the Study Three was to further investigate the higher order language skills of children with SLI, RLTs, and typically developing children. To the author's knowledge, only two studies have investigated global plot structure, linguistic complexity, and the use of evaluative devices in RLTs (Manhardt & Rescorla, 2002; Paul, Hernandez, Taylor, & Johnson, 1996); only one of these compared performance to that of children who continued to show deficits in expressive language (Paul, et al., 1996).

Global Plot Structure

Consistent with the findings of Norbury and Bishop (2003), there were no significant group differences between children with SLI and typically developing children on the measure of global plot structure. The mean group scores were quite low; in fact, they were less than half of the maximum score of twelve. This finding is not surprising given that all of the children were in the process of developing narrative skills. It is not until the ages of 9 to 10 years that children begin to demonstrate well-formed global-level organisation of narrative structure (Berman, 2009). Therefore, if we were to follow these children and look at their narrative discourse in later childhood and early adolescence, once narrative skills are more developed, differences between the groups may be more apparent. These results are also in accordance with Liles, Duffy, Merritt and Purcell's (1995) argument that global structure measures are not sensitive enough to distinguish language-impaired children from typically developing children.

Inconsistent with hypothesis two, relative to children with TLD, the RLTs included a similar number of core story components in their narratives. Although parametric tests did not reveal significant differences between children with SLI and RLTs on the number of components included, further investigation revealed that RLTs were more likely to have higher global plot structure scores than children with SLI. That is, children with SLI were more likely to provide less information about what happened in the story. Across groups, most children provided an adequate story setting; however, many children failed to identify the switch or provide a resolution to the initiating event. These components required the children to infer the causal relationships between the pictures rather than simply describe the pictures in the book as a series of unrelated events. In narrative (1), for example, the RLT identified most of the components depicted in each picture of the storybook, but did not identify the components of the story that required the integration of information across pictures:

(1) Ok, um…a boy's feeding…<u>a boy's feeding some fish</u>. A boy's feeding a fish. A boy's walk, A boy… <u>A boy is walking</u> to work. He's talking at some people. He's going to buy a…that fish. No, he's gone to buy fish friend. And he…<u>and he buyed it</u>. And he's walking. And <u>he said hello to some girls</u>. And he's getting some ice-cream. And he sit down and eat ice-cream. And he said "bye-bye" and he went home. And he asked his mum something. And <u>his friends comed ove</u>r. And he's got some fish.

[RLT, ID 0424, 5;5; Global structure score = 5]

The nature of the ERRNI task may limit the extent to which these findings may be generalised. The Fish Story represents only one genre of oral narrative discourse, that of a sequential, goal-based fictional story. Within the social and academic settings, children are often required to produce several types of narratives, including fictional narratives, personal accounts of events, or summaries of readings. Therefore, future research comparing the narrative abilities of children with typical development to those of children with SLI and RLTs might utilise a range of narrative genres.

Length of Narrative

In many respects the narratives produced by each group were quite similar. Consistent with hypothesis three, the group of children with SLI produced narratives of similar length, indexed by the number of clauses, and provided a similar range of different verbs compared to the groups of RLTs and typically developing children. Furthermore, the majority of verbs used by all of the children were action verbs. These findings are in line with those of Norbury and Bishop (2003) with older children with SLI. However, the current study also found that the RLTs were more likely than the children with SLI to produce longer narratives and use a larger range of different verbs. Of note, nonparametric tests confirmed that the RLTs used a similar number as well as a similar range of verbs when generating a narrative compared to children with TLD. As children get older and their linguistic abilities develop, group differences may become more apparent or subgroups might emerge.

It should be noted that there was large variability in the number of clauses produced for all three group. For example, three children with SLI were observed to generate exceptionally long narratives of 42 or more utterances. Further inspection of these three children's narratives revealed that for two of the children the number of subordinate clauses produced was well above the group mean, and for all three children the number of evaluative devices used was higher. However, interestingly, the child with the longest narrative did not produce any complex sentences. The narrative generated by this child is given in Appendix F. Furthermore, although these children produced long narratives, the narratives contained few main story components (four to six). The heterogeneity in the language abilities of children with SLI could in part explain this variance. Given the small numbers of children with Expressive-SLI, Receptive-SLI, or mixed-SLI, statistical analyses comparing the three groups could not be performed.

Syntactic Complexity

No evidence was found to support hypothesis four; the children with SLI and typically developing children did not differ on the number of subordinate clauses produced. This finding contrasts with the results of Norbury and Bishop (2003), who found that syntactic measures, such as sentence complexity, distinguished children with SLI aged 6 to 10 years from children with TLD. Once again, the young age of the children in the current study is the likely explanation. The use of complex syntax is an important linguistic tool that enables narrators to mark temporal and causal associations between story events (Capps, Losh, & Thurber, 2000). Preschool children tend to connect events in a linear fashion and, therefore, their use of complex syntax is limited. By age 9 years, children are organising their narratives into causal-temporal hierarchical structures and demonstrate increasing use of complex syntax to contrast main events with background information (Karmiloff-Smith, 1985). Therefore, the lack of group differences in this study can be accounted for by the developing linguistic skills in this sample of 5-year-old children. However, the standard deviations suggest that there is also great variability in narrative development in typically developing children. The wide range of scores observed is consistent with the work of Redmond, Thompson, and Goldstein (2011), who also found large within-group variability in 7- and 8-year-old typically developing children on a composite measure of children's overall narrative proficiency.

As expected the RLTs produced a similar number of subordinate clauses relative to children with TLD. Manhardt and Rescorla (2002) found late talkers who at 9 years-of-age performed within normal limits on language and nonverbal measures, scored similar to their peers with TLD on a measure of complex syntax. Of note, in the current study, when compared to children with SLI, RLTs were more likely to use subordinate clauses in their narratives. Overall, these findings suggest that despite an initial delay in expressive language, RLTs demonstrate unimpaired higher order language skills at age 5 years, when compared with typically developing children.

Evaluation

In keeping with previous findings (Norbury & Bishop, 2003), the SLI and TLD groups in the current study did not differ in their overall use of evaluative devices or in the range of evaluative devices used, and nor did the RLT group differ from these groups. Recall that evaluative devices convey the narrators' point of view and maintain listener involvement. Across groups children produced, on average, only two to three evaluative comments in their narratives. It appears that the children concentrated on discussing what was the focus of the pictures, for example, the boy feeding his pet-fish, and not on the elaboration of the narrative, for example what the character knew, thought, or felt. For example, narrative (2) from a female RLT includes multiple main story components, but no evaluative comments:

(2) The mum's walking in the room. [prompt] The boy's feeding the fish. The mum gave him money. She's walking somewhere. She walked on the footpath. She came to the pet store. He bought some fish. He was walking home. Then he saw some friends. She…he walk…he gave the fish to someone's children and he walked back. Then they all talked together. Then they all had ice-cream together. Then he waved at, to the person. Then he found a doll in the, his suitcase. Then his mum called someone on the phone. Then the people that had their fish came to their house. Then he showed them the fish.

[RLT, ID 0741, 5;5]

Bamberg and Damrad-Frye (1991) found that the use of evaluative devices increases with age, with adults using three times as many evaluative devices as 5-year-old children. However, whilst Bamberg and Damrad-Frye found 5-year-old children to have no clear preference for any particular device, the current study showed that children from all three groups used character speech more than any other evaluative device. This, however, may be related to the story content. Bamberg and Damrad-Frye did not use the ERRNI Fish Story, which involves interactions among the characters; they used the Frog Story (Mayer, 1969), which focuses upon a search without any obvious conversations. Overall, these findings suggest that the 5-year-old children in the current study use a restricted repertoire of strategies for engaging the listener whilst telling a narrative such as one based on the Fish Story. This presumably is based on their experiences with situations such as those depicted in the pictures: talking to ones mother, buying something, and meeting friends.

Cohesion

In the current study, the majority of children from each group assumed listener's knowledge by introducing the main character with a definite noun phrase or a pronoun. This is not a mature style for introducing referents. While the use of pronouns, definite nouns, and zero anaphora were all used to maintain referents, the majority of children did not use these expressions appropriately to produce a connected discourse. Karmiloff-Smith (1985) found children aged 4- to 5-years to use nominal devices such as definite articles and pronouns with a deictic function, with each device functioning on its own and not being linked intra-linguistically to the other referential devices used, that is, not linking to something introduced before. Consistent with Karrmiloff-Smith's findings with children of a similar age, the narratives produced by the children in the current study were largely stimulus driven with a focus on the main events and the boy's activities. The young children tended to use referential terms deictically, that is, the referent was dependent on the context in which it was said; for example, *He arrived at the shop. The boy bought a fish*. Examples (3) and (4) are two of the narratives produced. A child with SLI produced narrative (3) and a typically developing child produced narrative (4).

(3) He can reach the fish food. And then…then he walked to his mother and said….I don't know [general comment]. He walked to his mother and she gave something to him. And then he walked to somewhere. Then he saw a motorbike driving past. Then he was at the pet-shop buying a new fish. Then she gave it to him. Then he was walking along. And then she saw some children walking by. Then she and him was walking. And then they were walking together. Then they got a ice-cream. That one had a pink one. That one had a chocolate one and that one had a white one. And then he waved goodbye. And then he was going home, but he saw someone's doll. And then he had to do that another day. Then one morning his mother rang someone. And someone… then then … then someone arrived and left something. And then the children saw a little fishies and a big fish.

[SLI, ID 0406, 5;2]

(4) He's feeding his fishie. And he's looking. He's getting some money. And he's got a bag. And he went to the pet-shop. And he went, walking the path and then to the pet-shop. He pointed that fishie. Then he got the toy fishie. Now he's walking back from passing ice-cream shop. It's changing ways. And now he's having an ice-cream. And now he's going back. And now he's back home. And he pulled out a dolly of his bag. The sun is up. And his mummy's talking on the phone. And now his friends came. And now they're playing.

[TLD, ID 1805, 5;5]

In both of these examples, the children introduced the referent with a pronoun, presumably knowing that the listener could see the series of pictures and knew the identity of the character. The use of visual prompts to elicit narratives where both the child and listener are seated side by side might encourage greater deictic pronominal usage (Wigglesworth, 1990). The children maintained reference to the main character with pronouns or possessive expressions, referring also at times to the secondary characters. Subsequently, for the listener, the referential terms were ambiguous. Introducing characters in an unambiguous way and keeping track of shifts in references from one character to another, so that the listener can understand the main events in the story, requires cognitive resources that typically develop around the age of 7 years (Bamberg, 1987). Similarly, Karmiloff-Smith (1981; 1985) argued that children do not acquire the skills to adequately organise their narrative in terms of these linguistic elements until relatively late in their primary school years.

Wigglesworth (1990) demonstrated a developmental trend in introducing main characters with noun phrases. When introducing a main character, she found that only 5% of the 4-year-old children used a noun phrase, in comparison to 40%, 50%, and 70% of the 6- and 8-year-old children and adults, respectively; the 4-year-old children predominantly used pronouns. Furthermore, once secondary characters were introduced with a nominal, most of the 4-year-olds used pronouns deictically, rendering their narratives ambiguous.

Of note, in the current study, a small number of children from each group did use indefinite noun phrases to introduce the main character. Indefinite noun phrases do not assume mutual knowledge between the narrator (in this case, the child) and the listener, and therefore introduces the character in an unambiguous way. Example (5) is a narrative produced by a RLT who used an indefinite noun phrase to introduce the boy followed by a combination of indefinite noun phrases and pronouns to maintain reference to the boy. At this early stage of narrative development, Karmiloff-Smith (1985) suggests that the child’s primary goal is to match as closely as possible the pictorial stimuli. Despite a slightly more sophisticated approach to introduce the main character than in Examples (3) and (4), the child's output continues to be largely stimulus-driven.

(5) A boy's feeding…A boy's feeding some fish. A boy's feeding a fish. A boy's walk, a boy… A boy is walking to work. He's talking at some people. He's going to buy that fish. No, he's gone to buy fish friend…and he and he buyed it. And he's walking. And he and he said hello to some girls. And he's getting some ice-cream. And he sit down and eat ice-cream. And he said "bye-bye". And he went home. And he asked his mum something. And his friends comed over. And he's got some fish.

[RLT, ID 0424, 5;5]

Relationships among Aspects of Narrative Discourse

A goal of this study was to investigate the relationships among the different aspects of narrative discourse. For all three groups, story length was significantly related to lexical diversity, the number of subordinate clauses and the total number of evaluative devices. Longer stories provide more opportunities to use complex sentences and evaluative devices. The significant correlations among the various elements of narrative also suggest that they tap into the same underlying knowledge.

For each group, a moderate to strong correlation was found between global plot structure and verb types. Once children have the global plot structure in place, they have the cognitive resources available to think about what makes a good story; for example, they can draw on their knowledge of specific events and use different verbs, rather than general all purpose verbs, such as *do* or *got*, when generating their narrative. Only for the SLI and TLD groups was global plot structure also significantly correlated with story length. Norbury and

Bishop (2003) suggested that through language, children learn about the mental and emotional states of others, and adequate vocabulary allows children to talk about the mental state of others. In support of this, for each group, a modest relationship was found between verb types, that is, the diversity of verbs used and evaluative devices, including references to frames of mind. Only for the typically developing children and the RLTs was the use of evaluative devices also correlated with the production of complex syntax. However, many of these significant correlations were due to a large extent to the length of the narrative. The longer the narrative produced, the higher the global structure score and syntactic complexity score and the greater the score for evaluative devices.

Conclusion

The findings of the study extend existing knowledge of the narrative abilities of children who were late talkers at age 2 years and go on to demonstrate language abilities within the normal range at 4 years of age. Overall, the 5-year-old RLTs in the current study had age-appropriate narrative skills, in that they did not differ significantly from the typically developing children. In fact, in comparison to the SLI group, the RLTs were more likely to have higher global plot structure scores, longer narratives, and use a greater number of different verbs and more subordinate clauses. The study also demonstrates that the narratives of children with SLI were not significantly different from those of typically developing children.

Variability in all three groups was found, particularly in the length of the narratives for the SLI group. For typically developing children, the linguistic, cognitive, and social-cognitive elements associated with narrative competence continue to develop through middle childhood as does the ability to integrate knowledge from these domains (Kemper, 1984). Therefore, further research with RLTs and children with SLI in longitudinal studies and varying the stimulus material will help us understand the trajectories of development for children with SLI and RLTs.

CHAPTER 8

GENERAL DISCUSSION

The development of language in late talking children is of clinical significance to practitioners providing early identification and intervention services (Roos & Ellis Weismer, 2008). Therefore, research in the area is important. The present study aimed to add to our understanding of the developmental trajectory of higher order language skills and working memory in children with SLI and RLTs. While assessment of working memory is commonplace in research studies of SLI, the only known study that has investigated all four components of working memory in the same sample of children with SLI is as yet unpublished (Hutchinson, 2009). Furthermore, most studies on memory of children with SLI recruit children from clinical samples and/or across a large age range. There is also a paucity of research investigating working memory in samples of children who were late talkers but who have recovered, and a paucity of research comparing the profiles of RLTs, children with SLI and typically developing children. The present research was designed to address these shortcomings by using Baddeley's theoretical model of working memory as the basis for investigating different components of working memory, namely, the phonological loop, visuospatial sketchpad, central executive, and episodic buffer in a community-based sample of children from a narrow age range (5;0 to 5;8 years). This research also examined the narrative abilities of the children and the relationship between language and impairments in working memory. Thus the research reported in this thesis is unique in both the populations examined and the parameters studied.

The results of the three studies are presented in detail in Chapters 5, 6, and 7. In this chapter the key findings from the studies are discussed.

Summary of Research Findings: Working Memory of Children with SLI and RLTs

Using Baddeley's (2000) model of working memory, Study One examined processing and storage capacity in children with SLI, RLTs, and children with TLD. Consistent with previous research (e.g., Archibald & Gathercole, 2007a; Hick, Botting, & Conti-Ramsden, 2005a; Nickisch & von Kries, 2009; Norbury & Bishop, 2002), children with SLI performed significantly poorer than both the RLTs and children with TLD on measures of the phonological loop. This demonstrates that children with SLI have markedly limited phonological working memory capacity to store and process phonological input, which impacts on their language development. The significantly poorer performance of the children with SLI on nonword repetition relative to their typically developing peers adds to previous research, which has consistently reported deficits in nonword repetition for children with SLI. As successful nonword repetition involves a number of additional processes, including speech perception, phonological knowledge, and motor planning, these skills may also be impaired in children with SLI and therefore warrant further study. The children with SLI also showed difficulties on the measure of the episodic buffer, relative to the RLTs and children with TLD, suggestive of difficulties integrating information. Together, these results add further support to arguments that sentence recall and nonword repetition can serve as clinical markers of persistent language impairment as seen in SLI (Redmond, Thompson, & Goldstein, 2011).

Study One also included tasks assessing the visuospatial sketchpad. In contrast to simple (storage only) visuospatial memory tasks, where no differences were observed, on the visuospatial dual processing task tapping into the central executive, group differences emerged between the SLI and TLD groups. Concurrent rehearsal of spatial information negatively impacted on performance on the dual processing task, suggestive of visuospatial capacity limitations in children with SLI. The RLTs also outperformed children with SLI on the visuospatial dual processing task. Of significance, the RLTs demonstrated a relative strength in the storage and processing of visuospatial material, relative to phonological material. Further studies are required to determine if this finding can be generalised and if so, could be suggestive of compensatory strategies involved for children who have delayed emergence of productive vocabulary.

On the verbal domain conditions of the dual processing task, all of the children had difficulty co-ordinating information processing resources and storage, a function of the central executive of working memory. Similarly, all three groups of children performed comparably on the measure of the central executive, backward digit recall. These findings are likely due to the substantial processing load of the tasks, as all of the children found the tasks difficult. Five-year-old children, both with early language delay and typical language development may have few resources to successfully allocate their attentional resources simultaneously to verbal processing and storage during complex memory tasks. In addition, the tasks depended on knowledge of digits, and some of the children didn't know their numbers. These results highlight the methodological issue of using tasks that require the identification of digits in such young children and imply that this task is not a good discriminatory tool for this age. Consistent with the research into the development of working memory in children which shows that working memory is just emerging at 4 years-of-age, it would be predicted that as memory develops, differences between the SLI and TLD groups might become evident on central executive tasks.

Despite an early history of language delay, the 5-year-old RLTs did not show deficits in working memory. Group differences found in previous studies with RLTs may be due to different populations of children. It is also possible that with retesting, some children with early language delay demonstrate apparent 'recovery' of language abilities due to the effect of regression to the mean on standardized language assessments. Research has documented that late talkers constitute a heterogeneous group. For example, those late talkers who catch up may have a history of limited social skills and internalizing behavioural problems, such as withdrawal (Desmarais, et al., 2008). Within the ELVS longitudinal study with a large community-based sample, Prior and colleagues (2008) showed that shy children scored significantly poorer than more sociable children on the CDI at 24 months. Furthermore, shy temperament was significantly associated with vocabulary development as measured by the CDI. Putting these findings together, the study highlighted the importance of temperament as a key influence on early language production or vice versa. These factors were not investigated in the current study and therefore warrant further investigation.

Summary of Research Findings: Narrative Abilities of Children with SLI and RLTs

Studies Two and Three aimed to ascertain whether late talkers ultimately recover and develop adequate narrative skills, or if late talking at 24 months of age is a risk factor for difficulties with narrative skills at school age. Narratives are a particularly sensitive tool for assessing higher order language skills and identifying discourse problems that may not be indentified in standardised language tests (Tager-Flusberg, 1995). The analysis of narratives elicited from a series of pictures tests the children's ability to sequence events and create a storyline.

Study Two investigated narrative generation, recall, and comprehension of the three groups of children, and explored the working memory mechanisms supporting these three areas. The results showed that the 5-year-old children with SLI provided equivalent amounts of information as the typically developing children when generating and recalling a narrative from a picture sequence. They were able to extract similar amounts of information and form a representation of the story in memory. This finding is consistent with that of Dodwell and Bavin (2008). When generating and recalling a narrative, the RLTs provided a comparable amount of information as children with TLD, which indicates that by age 5 years differences in higher order language skills are not evident between RLTs and children with TLD, although they have been reported particularly for older children (Manhardt & Rescorla, 2002). However, the 5-year-old children with SLI produced fewer main ideas when generating and also recalling stories after a short delay than the RLTs. Another finding to emerge from the current research is that children with SLI performed worse when answering questions that required inferencing in comparison to the RLTs and typically developing children. This supports a view that 5-year-old children with SLI have difficulty integrating information to draw conclusions about the intentions, thoughts, and emotions of characters when explicit information is not available. Despite an early delay of language, the RLTs did not show deficits in this area.

The findings of Study Two also implicate the role of the episodic buffer in the generation and comprehension of narratives by children with TLD and RLTs. This finding is expected given that the role of the episodic buffer is to integrate information from the components of working memory and long-term memory into a single coherent complex structure (Baddeley, 2000), and to generate and understand a narrative, the child must store a number of representations in memory while integrating new incoming material as well as information from long-term memory (Botting & Adams, 2005). Furthermore, for the children with SLI, performance on the CNRep, block recall, and recalling sentences tasks were all predictive of narrative comprehension. The different correlations among children identified with impaired language at 4 years, relative to those with normal language skills, could indicate that different processes may be contributing to their narrative performance.

Study Three investigated different characteristics of the children's narratives, namely: global plot structure, narrative length, syntactic complexity, evaluative devices, and referential devices. Overall, the 5-year-old RLTs in the current study appeared to have age-appropriate narrative skills, in that they did not differ significantly from the children with

TLD. In fact, in comparison to the SLI group, the RLTs were more likely to have higher global plot structure scores, include more clauses in their narratives, use more subordinate clauses, and show diversity in the verbs used. The study also demonstrated that the narratives of children with SLI, using these measures, were not significantly different to those of typically developing children. Regarding the cohesion of the narratives, the majority of children from each group assumed listener's knowledge by introducing the main character with a definite noun phrase or a pronoun. While the use of pronouns, definite nouns, and zero anaphora were all used to maintain referents, most children did not use these to produce a connected discourse. This supports the early work of Karmiloff-Smith (1981) who found that children under 6 years used pronouns deictically.

Variability was found in all three groups, particularly in the number of clauses in the narratives of the SLI group, supporting the view that there is great variability in narrative development, which takes place over a number of years (Berman & Katzenberg, 1998; Karmiloff-Smith, 1985). For typically developing children, it is not until the ages of 9 to 10 years that they begin to demonstrate increasing use of complex syntax to contrast main events with background information (Karmiloff-Smith, 1985).

Liles et al.'s (1995) proposed that global plot structure measures are not sensitive enough to distinguish language-impaired children from typically developing children who are still in the process of developing narrative skills. Therefore, if we were to follow these children and look at their narrative discourse in later childhood or early adolescence, once narrative skills are more developed, group differences may become apparent. In particular, it would be useful to follow this group of children to 9- to 10-years-of-age to determine if the RLTs and typically developing children perform similarly or are producing mature narratives as proposed by Berman and Katzenberg (1998).

Strength of the Research

There are a number of strengths of the current thesis, the first of which is that the children participating in this study were recruited from a large population-based sample, rather than from a clinical sample. A possible explanation for the different results between the current research and studies that recruit late talkers from specialised clinical services is the different sample base. Recruitment from a longitudinal study enabled the inclusion of late talkers whose early language delay had resolved by age 4 years in addition to children whose language delay was still evident at 4 years and who were classified as SLI. Thus, the findings from the present research can be generalised to other populations of children with SLI and RLTs from the general population. A feature of previous SLI research is the recruitment of children with SLI from a large age range. Most studies recruit from a wide age range in order to have enough power for statistical analysis, but memory develops throughout childhood and early adolescence and so an extended age range will undoubtedly include children at different levels of memory development and so matching not by overall group age but individually or controlling for age would be important. Thus another strength of the present research was the narrow and comparable age range of the children across all groups. The young age of the children was also a strength of the current research given that there are few published studies of children of comparable age. The current findings demonstrate the importance of measuring children's abilities early in development.

A unique contribution of this research to the SLI and RLT literature is the investigation of all four components of Baddeley's model of working memory, as well as narrative skills, simultaneously in the same sample of children. In addition to the phonological loop, visuospatial sketchpad, and central executive, which are all commonly discussed in the SLI literature, the episodic buffer was also investigated in the present research. The role of the episodic buffer is to integrate information held in short-term memory and long-term memory, and because children with SLI have been found to have difficulties on tasks assessing the episodic buffer, as in this study, children with SLI have some problems with the integration of information.

Implications of the Findings and Future Directions

As reported in past research, maintaining information in working memory and processing such information, particularly within the phonological loop and episodic buffer, are areas of difficulty for children with SLI. Children with SLI in this research also demonstrated impaired visuospatial working memory in tasks tapping into the central executive component of working memory. This suggests that the cognitive load and complexity of tasks is an important factor when investigating group differences. This finding is consistent with the work of Carpenter and colleagues (Daneman & Carpenter, 1983; Just & Carpenter, 1992), who argue that both storage and processing functions share a limited pool of resources and when the storage and/or processing demands of a task exceed the amount of resources available to the working memory system, a trade-off between storage and processing occurs, thereby often leading to smaller temporary storage capacity. The current research also contributed to the existing literature by demonstrating that despite delayed early language development, 5-year-olds do not necessarily show memory deficits compared to typically developing children. The RLTs in this study, in fact, demonstrated an advantage in the storage and processing of visuospatial material, relative to phonological material.

The research highlighted the importance of studying language development beyond the sentence level (Karmiloff-Smith, 1985). Relative to both typically developing children and RLTs, children with SLI demonstrated impaired skills for narratives, particularly poor inferencing, which was associated with limitations in working memory. Children who have narrative difficulties are often disadvantaged in the classroom setting, where proficiency in this area contributes to the acquisition of literacy (Epstein & Phillips, 2009; Paul, Hernandez, Taylor, & Johnson, 1996). Based on the findings reported in this thesis, narrative skills should be a continuing target for language intervention for children with SLI with programs targeting comprehension, production and recall skills.

The research reported in this thesis showed that the majority of RLTs demonstrated higher order language skills within average limits. That is, at the age of 5 years, there was no evidence for an underlying deficit for RLTs. However, these findings were based on group means. With sufficient resources, individual monitoring of late talking children in tasks requiring higher order language skills could be closely monitored as these skills are critical for academic and later vocational success (Roos & Ellis Weismer, 2008).

Despite the strengths of the research, the findings were limited by a number of factors including the over-representation of females in the RLT group. The lack of some group differences that might have been expected could be explained by the young age of the children, for whom working memory and linguistic skills are still at relatively immature levels. For example, narrative skills do not reach a mature level until 9 to 10 years of age (Berman & Slobin, 1994; Karmiloff-Smith, 1985). Given the differences in findings across studies with children of various ages, future research should consider the value of longitudinal studies to add to our understanding of the developmental trajectories of working memory and narrative skills for late talkers who resolve and those who go on to be language impaired. Such research would assist in the development of informed intervention programs for children with delayed language.

As in many previous studies with late talkers (e.g., Ellis Weismer, 2007; Zubrick, Taylor, Rice, & Slegers, 2007), identification of late talkers at 24 months depended on parent responses on the MacArthur-Bates CDI (Fenson et al., 1993), and while the CDI is a standardised and reliable source of information about the young child's communicative skills (Fenson et al., 2007), there are inherent issues in any parent-report measure. It is not known how parents decided on whether the children knew or understood the words. For example, some parents may be overly cautious and underestimated their child's developing abilities. Fenson et al. (2007) found that parents with lower levels of education, used as an index of low SES, often underreported their children's word knowledge on the CDI: Words and Sentences form. Arriaga, Fenson, Cronan, and Pethick (1998) offered two possible explanations as to why lower CDI scores are often reported for children from families with low SES, one of which implies that lower scores obtained by the children are authentic. Children from low SES backgrounds may acquire language skills at a slower rate than middle-class children as a consequence of a less favourable language environment. Alternatively, parents in the low SES group may be underreporting their children's language skills on the CDI forms, implying that children's language skills are better than their CDI scores reflect. In the current research, as presented in Chapter 5, there was quite an even spread of children from the three SES levels across groups, reducing the likelihood of differences in parent reporting between the groups. For example, 33.3% of the children with SLI, 28.2% of the RLTs, and 31.2% of the children with TLD were from the low SES LGAs.

The current research showed that in some areas the 5-year-old RLTs achieved higher scores than the children with SLI. Recall that the RLTs and children with SLI were late talkers at 24 months. Therefore, in an attempt to explore possible reasons as to why some children with a history of late-talking at 24 months go on to perform within average limits or better on language assessments at 4 years of age, whilst others are identified as SLI, the children's vocabulary scores at 12 or 24 months were examined. Vocabulary production and comprehension scores based on the CDI (Fenson, et al., 1993) at 12 and 24 months were compared across the two groups. Exploratory analyses revealed that neither the words comprehended [$t(61) = 0.75$, $p = .46$] and produced [$t(61) = 1.05$, $p = .30$] at 12 months nor words produced at 24 months [$t(61) = 0.19$, $p = .85$] significantly differed between the language delayed groups. Other factors that were not explored, such as temperament, behaviour characteristics, and access to intervention services between the age of 2 and 4 years might also contribute to the developmental trajectory of late talking children.

In conclusion, the current research contributes to the growing body of literature regarding the working memory and higher order language skills of children with SLI and provides new research findings on the outcomes of RLTs at age 5 years; it also offers new insight into the relationships between narrative abilities and working memory.

APPENDICES

Appendix A

Participant Information and Consent Forms

LA TROBE UNIVERSITY

The Royal Children's Hospital, Melbourne

School of Psychological Science
Faculty of Science
Technology and Engineering
Victoria 3086, Australia

Telephone (+613) 9479 1590
Facsimile (+613) 9479 1956

Flemington Road, Parkville
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Facsimile (03) 9345 5789
Web www.rch.org.au

PARENT/GUARDIAN INFORMATION STATEMENT AND CONSENT FORM

HREC Project Number: 27078

HREC Project Title: Associations between Memory and Language in 5-year-old Children Phase of the Early Language in Victoria Study (ELVS)

Thank you for taking the time to read this Information Statement. This Information Statement and Consent Form is 5 pages long. Please make sure you have all the pages.

For people who speak languages other than English: If you would also like information about the research and Consent Form in your language, please ask the person explaining this project to you.

Your child is invited to participate in a research project that is explained below.

What is an Information Statement?
These pages tell you about the research project. It explains to you clearly and openly all the steps and procedures of the project. The information is to help you to decide whether or not you would like your child to take part in the research.

Please read this Information Statement carefully. You can ask us questions about anything in it. You may want to talk about the project with your family, friends or health care worker.

Participation in this research project is voluntary. If you don't want your child to take part, you don't have to. You can withdraw your child from the project at any time without explanation and this will not affect their access to the best available treatment options and care from the Royal Children's Hospital.

Once you have understood what the project is about, if you would like your child to take part please sign the consent form at the end of this information statement. You will be given a copy of this information and consent form to keep.

---

1. **What is the research project about?**

The Early Language in Victoria Study (ELVS) aims to learn more about how language develops in young children. You and your child have been part of this study for over 4 years.

We are now conducting an extra phase of the ELVS study that is looking at how memory is related to language development in young children.

We already know some of the ways memory is related to language development. But now we want to look in more detail at how a group of children from the ELVS study with a range of language abilities perform on different memory tasks. We hope 150 children who are already taking part in ELVS will agree to participate in this extra phase.
The results of this research will increase our understanding of how memory and language fit together in children with a range of language abilities. This will help in the development of early intervention programs for children who have language difficulties.

2. Who are the researchers?

- Associate Professor Edith L. Bavin is a Psycholinguist from the School of Psychological Sciences at La Trobe University
- Dr Lesley Bretherton is a Psychologist from the Psychology Department at Royal Children's Hospital
- Nadia Petruccelli is a Provisional Psychologist at La Trobe University. The results of this research will be used to help Nadia Petruccelli fulfil the requirements of her postgraduate studies (Doctor of Clinical Psychology).

3. Why is my child being asked to be in this research project?
We are asking your child to take part in this project because he/she is a participant in the ELVS study.

4. What does my child need to do to be in this research project?
We would like to complete one face-to-face assessment with your child. This will take place at your local Maternal and Child Health Clinic, La Trobe University or your house, depending on what is convenient for you. The assessment will take no more than one hour.
We would like to complete some activities with your child that focus on language and memory. The activities are detailed below:

(a) telling a story from a set of pictures and answering some questions about the story,
(b) repeating words and numbers,
(c) copying patterns with blocks,
(d) remembering where things appeared in two short memory tasks.

We would like to audiotape and videotape some parts of the session, so we can focus on the activities and be able to check our scoring .
We would also like to use information from the questionnaire you completed when your child was 2-years-old and information from the assessment your child completed when he/she was 4-years-old. This information will help us to understand how your child's language ability has been improving over time.
If you agree to take part, please return a signed consent form. After we receive it, we will contact you to make an appointment for the session.

5. What are my child's alternatives to taking part in this project?
Your child does not have to take part if you do not want him/her to. If you decide to allow your child to take part and later change your mind, you are free to withdraw him/her from the project at any stage. If your child does not take part, or withdraws from this extra phase of the study, it will not affect his/her participation in the main ELVS study.

6. What are the possible benefits for my child?
We do not expect there to be any direct benefit to your child, although most children will enjoy completing the activities.

7. What are the benefits for other people in the future?
Your child's participation will help us to learn more about how memory abilities influence language development. The results of this research are important; they can help in the planning of assessment and intervention programs for children with problems in language development.

8. What are the possible risks, side-effects and/or discomforts?
We do not expect there to be any risks, side-effects or discomforts if your child takes part in this project. However, so that your child does not get too tired and is able to concentrate well during the assessment we will give him/her rest breaks as needed. If necessary, we will stop the assessment and discuss with you whether or not your child should continue with the activities.

9. What are the possible inconveniences?
The only inconveniences are the time taken to travel to the assessment and transport costs.

10. What will be done to make sure my child's information is confidential?
Any information we collect from your child will remain confidential. We will only use your child's information for the purpose of this research project. Only the researchers involved with this project and the Royal Children's Hospital and La Trobe University Ethics Committee can have access to this information. We can only disclose the information with your permission, except as required by law. You have the right to look at, and ask correction of, your child's information in accordance with the Freedom of Information Act 1982 (Vic).
The information will be re-identifiable. This means that we will remove your child's name and give the information a special code number. Only the research team will be able to break the code to match your child's name to the code number.
All information will be stored securely in a locked filing cabinet in the Language Research Unit in the School of Psychological Science at La Trobe University. Your child's information will also be stored on a password-protected computer database at La Trobe University and the Speech Pathology Department at the Royal Children Hospital.
As your child is aged under 18 years old we will keep the information until he/she turns 25 years old. After this time, we will destroy the information by shredding documents and deleting computer files.
When we write or talk about the results of this project, we will only report information about the whole group of participants. This means that no one will be able to identify your child. We plan to share the group results with other health professionals, for example, at conferences, seminars and by publishing them in professional journals.

11. Will we be informed of the results when the research project is finished?
We will send you a summary of the overall group results at the end of the project.

If you would like more information about the project or if you need to speak to a member of the research team in an emergency please contact:

Name: Nadia Petruccelli
Contact telephone: 9479 3412

If you have any concerns about the project or the way it is being conducted, and would like to speak to someone independent of the project, please contact:

Head of Department
Ethics and Research Department
Human Research Ethics Committee
Telephone: (03) 9345 5044

OR

Secretary, Human Ethics Committee
Research and Graduate Studies Office
La Trobe University
Telephone: (03) 9479 1443,
e-mail: humanethics@latrobe.edu.au

LA TROBE UNIVERSITY

The Royal Children's Hospital, Melbourne

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Facsimile (03) 9345 5789
Web www.rch.org.au

CONSENT FORM FOR PARENT/GUARDIAN TO GIVE INFORMED CONSENT FOR THEIR CHILD TO TAKE PART IN A RESEARCH PROJECT

HREC Project Number: 27078
Research Project Title: Associations between Memory and Language in 5-year-old Children Phase of the Early Language in Victoria Study (ELVS)

Researcher(s): Edith L Bavin, Lesley Bretherton, Nadia Petruccelli

I (Parent/Guardian's name) ______________________________

Of (child's name) ______________________________

voluntarily consent for me and my child to take part in the above research project

- I believe I understand the purpose, extent and possible effects of my involvement in this project.
- I have had an opportunity to ask questions and I am satisfied with the answers I have received.
- I have received a copy of the Parent/Guardian Information Statement and Consent Form to keep.

Please tick the box or boxes if you also agree to:

☐ Give consent for my child to be video-recorded.
☐ Give consent for my child to be tape-recorded.

Parent/Guardian Signature ____________________ **Date** ____________

For office use only:
I have supplied an Information Statement and Consent Form to the parent/guardian who has signed above, and believe that they understand the purpose, extent and possible effects of their involvement in this project.

Researcher's Signature ____________________ **Date** ____________

Note: All parties signing the Consent Form must date their own signature.

LA TROBE UNIVERSITY

The Royal Children's Hospital, Melbourne

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HREC Project Number: 27078

Research Project Title: Associations between Memory and Language in 5-year-old Children Phase of the Early Language in Victoria Study (ELVS)

Researcher(s): Edith L Bavin, Lesley Bretherton, Nadia Petruccelli

I (Parent/Guardian's name) ______________________________

Of (child's name) ______________________________

do not consent for me and my child to take part in the above research project

I understand that by opting out of this new phase of the ELVS study, I/we will continue to be part of the overall ELVS study.

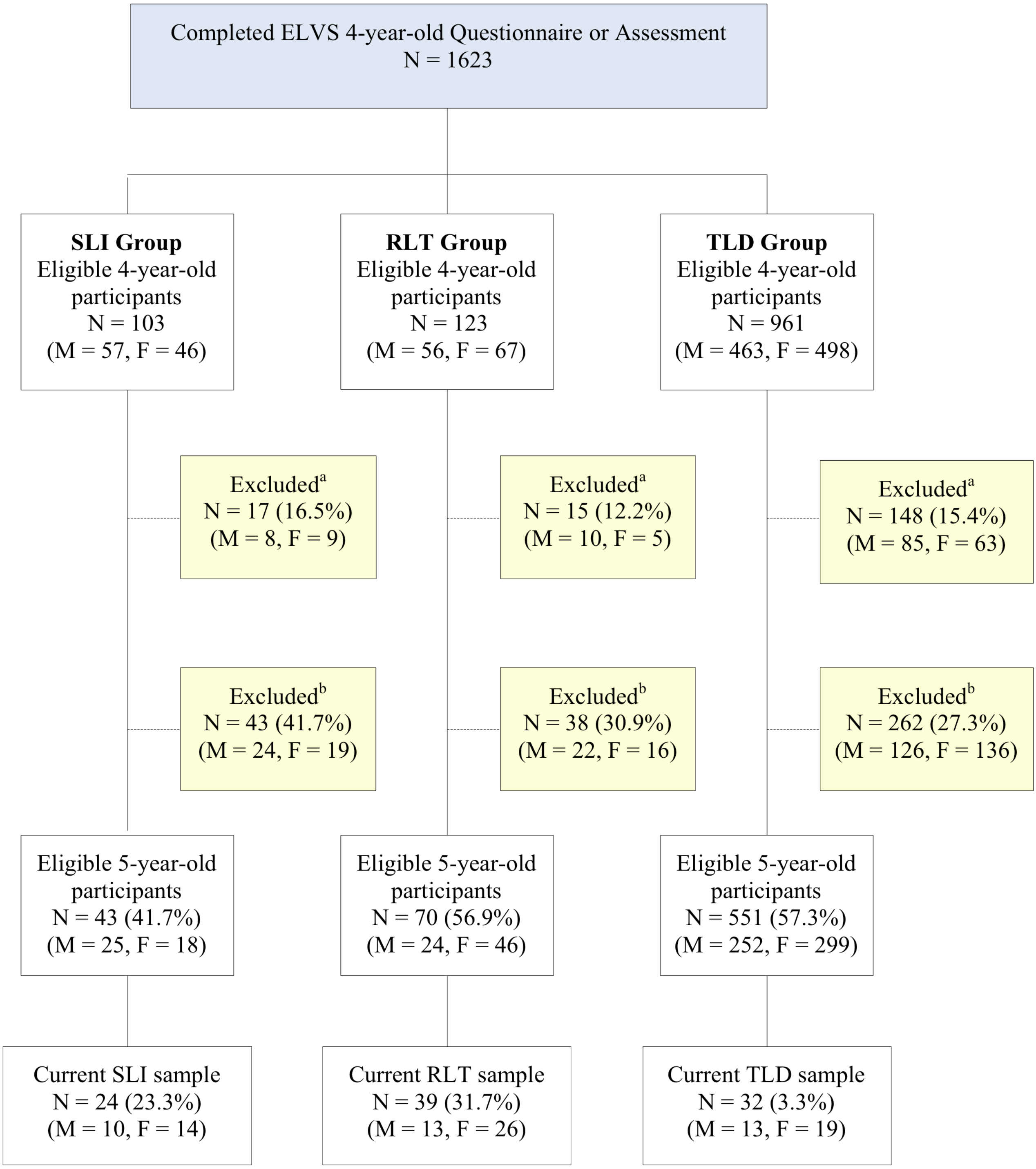
I understand that there will be no disadvantages or penalties for not participating in this extra phase of the ELVS study and there will be no effect on my/our child's access to the best available treatment and care at the Royal Children's Hospital (Melbourne).

Parent/Guardian Signature ______________________ **Date** ______________

Note: All parties signing the Consent Form must date their own signature.

Appendix B

Flowchart of the Number of ELVS Children (broken down by Language Group and Gender) from the ELVS 4-year-old Assessment to Participation in the Current Study



[a] Number of cases excluded due to child taking part in another sub-study of ELVS. [b] Number of cases excluded due to no 5-year-old assessment data. M = Males, F = Females.

Appendix C

Ethics Approval Certificates

Appendix C1: La Trobe University Ethics Approval Certificate

LA TROBE UNIVERSITY

RESEARCH AND GRADUATE STUDIES OFFICE

MEMORANDUM

To:	**Dr Edith Bavin, School of Psychological Sciences, FST&E** **Ms Nadia Petruccelli, School of Psychological Sciences, FST&E**
From:	**Secretary, La Trobe University Human Ethics Committee**
Subject:	**Review of Human Ethics Committee Application No. 07-150**
Title:	***Associations between Memory and Language in 5-year-old Children***
Date:	**17 January 2008**

Thank you for submitting revisions to your application for ethics approval to the La Trobe University Human Ethics Committee (UHEC) for the project referred to above. Your response was forwarded to a subcommittee of the UHEC, who has assessed the project as complying with the National Health and Medical Research Council's National Statement on Ethical Conduct in Human Research and with University Human Research Ethics Guidelines.

Your project has been granted ethics approval and you may commence the study.

The project has been approved to 31 August 2010.

Please note that your application has been reviewed by a sub-committee of the UHEC in the interest of facilitating a decision on your application before the next committee meeting. The decision to approve your project will need to be ratified by the full UHEC and consequently approval for your project may be withdrawn or conditions of approval altered. However, your project may commence prior to ratification of the approval decision. You will be notified if the approval status of your project is altered.

The following standard conditions apply to your project:

- **Complaints.** If any complaints are received or ethical issues arise during the course of the project, researchers should advise the Secretary of the UHEC on telephone (03) 9479 1443;

- **Limit of Approval.** Approval is limited strictly to the research proposal as submitted in your application while taking into account the conditions and approval dates advised by the UHEC;

- **Variation to Project.** As a consequence of the previous condition, any subsequent variations or modifications you may wish to make to your project must be notified formally to the UHEC. This can be done using the appropriate form (*Application for Approval of Modification to Research Project)* which is available on the internet at http://*www.latrobe.edu.au/www/rgso/ethics/ethics.htm* or from the UHEC Secretary in electronic or hard copy. If the UHEC considers that the proposed changes are significant, you may be required to submit a new application form for approval of the revised project;

- **Progress Reports.** You are required to submit a *Progress Report* form annually, by 12 February (if your project continues for more than 12 months) and at the conclusion of your project. The form is also available on the internet (see above address) and can be collected in electronic or hard copy. When completed the form should be returned to the Secretary of the UHEC. Failure to submit a progress report will mean approval for this project will lapse. An audit may be conducted by the UHEC at any time.

A **Final Report** will be due by **28 February 2011.**

If you have any queries on the matters mentioned above or require any further clarification please contact me at the Research and Graduate Studies Office on telephone (03) 9479 1443, facsimile (03) 9479 1464 or e-mail address humanethics@latrobe.edu.au

On behalf of the UHEC, best wishes with your research!

Barbara Doherty
Administrative Officer (Research Ethics)
La Trobe University Human Ethics Committee

Appendix C2: The Royal Children's Hospital Approval Certificate

The Royal Children's Hospital, Melbourne

Flemington Road, Parkville
Victoria, Australia, 3052
Telephone (03) 9345 5044
Facsimile (03) 9345 5196
Email: rch.ethics@rch.org.au
Web: www.rch.org.au/ethics

ETHICS & RESEARCH DEPARTMENT

12 December, 2007

Prof Sheena Reilly
Speech Pathology Dept
RCH/MCRI

Dear Prof Reilly,

Re: Approval of **HREC 27078 D**

Please find attached The RCH HREC approval certificate for the **MODIFICATION** of the project "Understanding how language and reading problems develop: a population based longitudinal study from infancy to age 7" for which you are listed as the contact person.

Documents approved for this modification are as follows:

- Research Protocol v4 dated 19th Nov 2007
- PGIS (memory and language) v1 dated 19 Nov 2007
- Appointment letter (memory and language) v1 dated 8th Oct 2007

Please inform the Ethics & Research Department if there are any omissions from the above list.

Please note that this project was recommended for Chairman's approval (expedited review). All Chair approvals require ratification at the next Human Research Ethics Committee meeting, at which time there is a possibility that your project application may be reconsidered by the Committee, and further questions raised.

Please also note the conditions of ethics approval which have been listed on the certificate.

The Committee wishes you well with the continuation of your study.

Yours sincerely,

Ethics and Research Department, on behalf of
The RCH Human Research Ethics Committee

The Royal Children's Hospital, Melbourne

Flemington Road, Parkville
Victoria, Australia, 3052

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ISD (+613) 9345 5522
Facsimile (03) 9345 5789

RCH HUMAN RESEARCH ETHICS COMMITTEE APPROVAL

HREC REF. No:	**27078 D**
PROJECT TITLE:	Understanding how language and reading problems develop: a population based longitudinal study from infancy to age 7.
Documents approved:	Research Protocol v4 dated 19th Nov 2007 PGIS (memory and language) v1 dated 19 Nov 2007 Appointment letter (memory and language) v1 dated 8th Oct 2007
INVESTIGATOR(S):	S Reilly, M Prior, A Castles, M Wake, E Bavin, J Carlin, P Eadie, L Bretherton, O Ukoumunne, L Conway, J Skeat

DATE OF MODIFICATION APPROVAL: **12th December 2007**

DURATION: 33 months

DATE OF APPROVAL EXPIRY: **13th September 2010**

SIGNED: 18/12/2007
COMMITTEE REPRESENTATIVE

COMMENTS:

APPROVED SUBJECT TO THE FOLLOWING CONDITIONS:

ALL PROJECTS

1. Any proposed change in protocol or any approved documents or the addition of any documents (including flyers, brochures, advertising material etc) and the reasons for that change or addition, together with an indication of ethical implications (if any), must be submitted to the Human Research Ethics Committee for Approval prior to implementation.
2. The Principal Investigator must notify the Secretary of the Human Research Ethics Committee of:
   - Any adverse effects of the study on participants and steps taken to deal with them.
   - Any unforeseen events.
   - Investigators withdrawing from or joining the project.
3. A progress report must be submitted annually and at the conclusion of the project, with special emphasis on ethical matters.
4. All research information collected whilst individual participants are children must be kept until the individual turns 25 (i.e. 7 years after their 18th birthday).

Please note that it is the investigators responsibility to ensure that the RCH HREC Approval remains current for the entire duration of the project. Investigators undertaking projects without current HREC approval risk their indemnity, funding and publication rights.

DRUG/DEVICE TRIALS

5. The investigator(s) must report to the Sponsor and the Human Research Ethics Committee within 24 hours of becoming aware of any serious adverse event experienced by any subject during the trial.
6. The investigators must ensure that all externally sponsored Clinical Drug Studies have insurance coverage that is current for the duration of the study.

Appendix D

Number of Lower and Upper Bound Outliers in each Group on the Measures of Working Memory

	Lower Bound Outliers			Upper Bound Outliers		
	Group			Group		
Variable	SLI	RLT	TLD	SLI	RLT	TLD
Digit Recall	1	0	0	1	0	0
CNRep	0	0	0	2	0	0
Picture Locations	0	1	0	0	0	0
Backward Digit Recall	0	0	1	0	1	2
Recalling Sentences	0	0	1	0	0	0

Appendix E

Description of ERRNI Fish Story Pictures

Picture 1: A boy is feeding a fish

Picture 2: The mother is giving the boy money

Picture 3: The boy is walking down a path

Picture 4: The boy is walking down a street near a pet store

Picture 5: The boy is choosing a fish from the pet shop

Picture 6: The boy is watching as a fish is being placed his red bag by the shop keeper

Picture 7: The boy is walking out of the pet store

Picture 8: The boy meets two girls outside a food stand; one girl has a yellow bag.

Picture 9: The boy goes with one of the children to the food stand while the second child removes the content of both children's bags (a fish from the boys red bag and a doll from the girls yellow bag)

Picture 10: The three children are eating ice cream

Picture 11: The child takes his red bag and waves goodbye to the two other children, one of whom is carrying their yellow bag.

Picture 12: The boy arrives home and shows his mother a doll from his red bag.

Picture 13: The mother is shown on the telephone

Picture 14: The three children are in the boy's home standing around the girl's doll

Picture 15: The young girl is holding her doll and the boy is showing both girls his two fish.

Appendix F

Narrative Example: Longest Narrative Generated by a Child in the SLI Group

5;4 year-old female with SLI (ID 690)

There's a fish

And there's a mum coming

And…and she just smiled

And the boy just feeded his fish

And there's books

And and the mum gave him money

And and he put it in his pockets

And um the fish um swimmed

And the mum just…the mum just walks

And one person is…um one boy just um drives from the motor-…motor-bike um on the road

And boys and girls um going on the park

And there's houses and roads and parks

And …and um…and the lady um give a um said um…the boy just um, "Can I've that fish please?"

And he loves fishes

And there's rabbits

And there's birdies

And fishes

And little fishes

And there's rubbish bins

And …um little mice

And and there's a fish

One fish in the bowl

And one there, in the bucket

And there birdie and mices, there's rabbits

There's a lady walking past the shop in the gate

And there's and there's a… and there's a girl, girl, girl walking and said, "Do you want to play with us today?"

And and the girl um two girls um walked back all the way home

And one two three had ice-cream

And and they sit down, eat it

And then they walked past

And they said to the um the man, "Can I have some ice-cream? Can I, white, and strawberry and chocolate, please?"

And the…and he said, "Yes, I'll served it up"

And the boy said, "Goodbye"

And the the mum just got um… the mum just said, "What do you got?"

And she …and he um got a fish, two fishes and a doll

And and the phone just ringed

'Ring-ring ring-ring'

And and she just um um …just pick up the phone

And they just talk

And um… the girl said, 'Do you want to come…Can I go to his house?"

And he … she said, "Yes"

And and he didn't talked

He did talked

And then um he just smiled and smiled and smiled and smiled

And and then um and there's a doll

And the big girl just got the um…bag

And the boy got bag

And um the girl didn't have a bag

And her just have the doll

And she got…and he got two fishes

One of a big one

One a little one.

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