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Specific language or working memory impairments: A small scale observational study

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Specific language or working memory impairments: A small scale observational study

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Abstract
Study of the developmental relationship between language and working memory skills has only just begun, despite the prominent role of their interdependency in some theoretical accounts of developmental language impairments. Recently, Archibald and Joanisse (2009) identified children with specific language impairment (SLI), or specific working memory impairment (SWMI), or mixed language and working memory impairment (Mixed) based on standardized testing. In the present study, we report a first effort to provide clinical verification of these profiles by describing the social, behavioral, and academic characteristics of individual group members. Two each of children with SLI, SWMI, or Mixed impairments, individually paired with six typically developing classmates, were observed in their classroom, and their teachers completed questionnaires related to communication, working memory, and attention. Children with impairments were distinguished from typically developing children; however, relatively few patterns further distinguished the children with SLI, SWMI, and Mixed impairments. Interestingly, the children with memory impairments were found to have some language-related difficulties, and the children with language impairments, some memory-related difficulties. The limitations of these preliminary findings and future directions are discussed.

Keywords
specific language impairment, working memory, observation

I Introduction

Children develop at different rates across a number of cognitive domains. Children who fail to progress as expected are a particular concern because of the resulting hardship such limitations may cause for the individual, family, and society at large. Language and memory skills are two highly related but distinct neurodevelopmental domains important to an individual's future academic and

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socioeconomic success. Developmental deficits in language skills have been relatively well described (e.g. Leonard, 1998) and have been linked to impairments in working memory, the ability to briefly store and process information (e.g. Montgomery, 2002; Archibald and Gathercole, 2006; Montgomery et al., 2010). Impairments in working memory development have received considerably less attention (Alloway et al., 2009) with the associated language characteristics remaining virtually unknown. Interestingly, deficits in both language and working memory often co-occur in children with exceptionalities such as specific learning disabilities (SpLD) and attention deficit hyperactivity disorder (ADHD) (Edmunds and Edmunds, 2008). In a recent study, Archibald and Joanisse (2009) explored the developmental relationship between language and working memory by examining these skills in an unselected group of school age children and identifying individuals with deficits in either language or working memory, or both. The purpose of the present study was to describe the social, behavioral, and academic characteristics of children with each of these profiles.

1 Specific language impairment

The ability to acquire linguistic knowledge including the vocabulary, grammar, and syntax of our native language is a uniquely human trait. Our learning system seems particularly adept at encoding and retaining the phonological and semantic building blocks of language, and the rules for combining them. Yet, some children fail to learn language at the expected time or rate despite normal general intellectual abilities, sensory functions, and environmental exposure to language (Leonard, 1998). These children have a specific language impairment (SLI). Children with SLI tend to be impaired in virtually all aspects of language development including phonological skills (Bortolini and Leonard, 2000), vocabulary acquisition (Sheng and McGregor, 2010), and syntax (Marinellie, 2004). One of the hallmark findings in this area of research is that children with SLI have particular difficulty with grammatical skills such as marking of verb agreement (Leonard et al., 2000) and tense (Rice, 2003). Language assessments of these children include tasks requiring the production of grammatical markers, comprehension of syntactically complex sentences, and formulation of accurate sentences.

Diagnostic criteria for SLI based on both the World Health Organization's International Classification of Diseases (World Health Organization, 1993) and the American Psychiatric Association's Diagnostic and Statistical Manual (American Psychiatric Association, 1994) generally include the following:

1. language skills more than 2 standard deviations below age expectations on standardized tests;
2. language skills at least 1 *SD* below scores on a standardized test of non-verbal intelligence; and
3. absence of a pervasive developmental disorder, or a neurological, sensory, or physical impairment that directly affect spoken language.

A distinction is drawn in the ICD-10 (World Health Organization, 1993) between a receptive language disorder characterized by language comprehension scores more than 2 *SD* below age level, and expressive language disorder where only the expressive scores fall more than 2 *SD* below age level. Nevertheless, despite our best efforts to specify and quantify SLI, children with SLI remain a notoriously heterogeneous group with varying deficits, not only in primary linguistic characteristics but in non-verbal ability as well (Botting et al., 2001). Considerable efforts have been made to understand this heterogeneity by identifying subgroups within SLI (e.g. Rapin and Allen, 1983,

1987; Wilson and Risucci, 1986; Conti-Ramsden et al., 1997; Tomblin and Zhang, 1999); however, a general consensus has yet to be reached.

Theoretical accounts of SLI have been a matter of considerable debate. Some theories focus on the specific language learning mechanisms implicated in the disorder (e.g. Rice, 2003; van der Lely, 2004). While these theories may explain the grammatical or syntactical deficits observed in SLI, impairments outside of the linguistic domain are more problematic for such accounts. Another set of theories implicates general information processing in SLI. SLI groups have been found to have slower reaction times to both verbal and non-verbal material (e.g. Montgomery, 2000; Miller et al., 2001; Schul et al., 2004), and to perform more poorly as information processing demand increases (e.g. Johnston and Smith, 1989; Ellis Weismer and Hesketh, 1993, 1996). Such findings have led to the proposal that children with SLI have reduced information processing speed (Kail, 1994) or capacity (Bishop, 1992; Ellis Weismer and Evans, 2002). According to these theories, the processing deficit has a disproportionate impact on language learning due to the time-sensitive and complex nature of language, respectively.

Deficits in the ability to repeat non-words have been reported consistently for SLI groups (e.g. Dollaghan and Campbell, 1998; Conti-Ramsden, 2003; Montgomery, 2004; Archibald and Gathercole, 2006). According to one prominent account (Gathercole and Baddeley, 1993), non-word repetition provides a relatively pure measure of phonological short-term memory and the non-word repetition deficit in SLI thus reflects a phonological short-term memory impairment. A phonological short-term memory deficit alone, however, does not appear to provide a full account of SLI in that poor phonological short-term memory alone has not been found to result in a lasting language impairment. For example in one study, children with a history of phonological short-term memory deficits at four years of age were found to have age-appropriate language abilities four years later (Gathercole et al., 2005). Recent research has suggested that a variety of factors influence non-word repetition including phonotactic frequency (Munson, 2001), vocabulary knowledge (Edwards et al., 2004), and prosodic cues (Archibald et al., 2009),

Findings related to both the information processing and short-term phonological storage deficits in SLI have led to the suggestion that a working memory impairment may underlie SLI (Ellis Weismer, 1996; Montgomery 2000, 2002; Montgomery et al., 2010). In a recent study comparing working memory skills in school age SLI and typically developing groups, Archibald and Gathercole (2007a) reported slower processing of both verbal and visuospatial material combined with a phonological short-term memory deficit in the SLI group. It was suggested that this combination of working memory deficits might be the key to a lasting and specific limitation in language learning (Archibald and Gathercole, 2007a). It can be readily argued, however, that this causal implication has not been adequately assessed. At present, the vast majority of studies investigating working memory and language impairment have set out to characterize the (poor) working memory abilities of a group with SLI (e.g. Ellis Weismer et al., 1999; Hoffman and Gillam, 2004; Ellis Weismer et al., 2005; Bavin et al., 2005). The untested assumption here is that working memory impairments always cause language impairments. Do they?

Archibald and Joanisse (2009) addressed this question in a study employing an epidemiological approach to examine the language and working memory skills of an unselected group of 400 children aged 5–9 years. They identified 30 children meeting criteria for SLI but these children differed on whether or not they exhibited working memory impairments. A group of seven children with SLI scored in the average range on all working memory tasks, whereas a group about twice as large ($n = 13$) presented with working memory deficits across domains. Importantly, the distinction between children with SLI only (without concomitant working memory impairments) and children with mixed language and working memory impairments (and, in fact, the existence of the former

group) fails to confirm a causal relationship between working memory deficits and SLI. While still preliminary, these results have important theoretical and clinical implications, and thus warrant further investigation as in the present study.

2 Specific working memory impairment

Working memory refers to our ability to briefly store and complete necessary cognitive processing on information held in our current focus of attention. According to most theoretical accounts (Baddeley and Hitch, 1974; Cowan, 2001), we have specialized abilities to briefly retain different types of information within domain-specific short-term memory stores. For example, verbal material may be held in phonological short-term memory without interfering with information retained in visuospatial short-term memory. Nevertheless, the real work of working memory is in the coordinated processing of the assembled information by the central executive function, and this capacity is domain-general in nature (Engle et al., 1999; Bayliss et al., 2003; Kane et al., 2004). Thus, processing demands tapping working memory constrain the amount of verbal or visuospatial information that can be managed by the system.

The assessment of working memory involves testing both short-term and working memory. Short-term memory tasks (also known as simple span tasks) require immediate repetition of phonological (e.g. words, non-words) or visuospatial material (e.g. shapes, locations). Working memory tasks (also known as complex span tasks) require some sort of information processing while retaining some aspect of the material. Tests of working memory may be verbal (e.g. repeat numbers in reverse order) or visuospatial in nature (e.g. mentally rotate a shape and remember orientation). Thus, verbal working memory tests tap both phonological short-term memory (for retaining verbal information) and the central executive component of working memory (for processing information) with impaired performances reflecting deficits in either component. Similarly, visuospatial working memory tests place demands on both visuospatial short-term memory and the central executive component of working memory with poor scores reflecting deficits in one of these components. Results of visuospatial and verbal working memory tasks taken together provide information about the component common to both tasks, the central executive. Deficits exhibited across verbal and visuospatial working memory tasks implicate a specific difficulty in the central executive role of working memory as the most parsimonious explanation.

Children with low working memory capacity have been described in only a few studies. Gathercole, Alloway, and colleagues (Alloway et al., 2008; Gathercole et al., 2008) have reported the characteristics of children scoring in the deficit range on two standardized verbal working memory tasks. In further testing, about two thirds of the group also scored poorly on visuospatial working memory tasks, vocabulary, reading and maths. Teachers judged these children as having cognitive problems, inattention, high incidences of failure to monitor the quality of work, and lack of creativity in problem solving. The researchers argued that their results established that children with poor working memory are at high risk for poor academic progress, and have distinctive behavior profiles of inattention and forgetting, causing disruptions to their classroom participation. The implication here is that working memory limitations constrain learning generally resulting in deficiencies across a number of domains. Converging evidence for the important role of working memory in learning throughout development comes from findings that working memory deficits are a common feature of diverse groups of individuals including those with attention deficit hyperactivity disorder (e.g. Martinussen and Tannock, 2006), Down syndrome (e.g. Laws, 2004), and learning difficulties in reading (e.g. Swanson, 2003) and mathematics (e.g. Gersten et al., 2005).

One problem with the Alloway et al. (2008) study described above is that they selected their low working memory group based on poor verbal rather than domain-general working memory performance. It must be acknowledged that difficulties in verbal working memory tasks may arise for reasons other than a working memory deficit. For example, children with SLI show a disproportionate deficit on verbal as compared to visuospatial working memory tasks (Archibald and Gathercole, 2007b). Only poor performance across both verbal and visuospatial working memory tasks can be considered to reflect a specific difficulty in the processing and storage of information: the central executive function (i.e. working memory), separate from the facility with the material itself. Only one study has adopted such a definition for working memory impairment. Archibald and Joanisse (2009) identified school age children as having a working memory impairment if they scored more than 1 *SD* below the standardized mean on both verbal and visuospatial working memory tasks. In addition to the SLI and Mixed language and working memory groups described above, this study also identified a group of seven children with a specific working memory impairment (SWMI). The SWMI group exhibited deficits across domains in working memory but had age-appropriate language skills.

3 The present study

Archibald and Joanisse (2009) described groups of children with SLI, SWMI, and Mixed language and working memory impairments. One of the limitations of this study is that individual profile designation was based entirely on standardized test performance. In order to determine if these profiles have any clinical significance, it is important to describe the everyday functioning of children exhibiting each profile. In particular, we were interested in whether the children with working memory impairment would present with learning challenges, and if these challenges would be different from those with SLI and depending on whether a concomitant language impairment existed. In the present study, we focused on school behaviors. One of the methods adopted was classroom observation, which involved a trained observer sitting inconspicuously in the classroom. Research suggests that teachers and students adjust quickly to the presence of an observer in the classroom such that typical classroom behaviors resume quickly after the introduction of the observer. '[A]n outside observer in the classroom over a period of time will be taken for granted, viewed as a part of the natural setting, and have little effect on the behavior observed' (Best and Kahn, 2006: 308). Naturalistic observation, then, provides an ecologically valid measure of daily functioning. Data collected may be quantitative such as the counting of behaviors of interest (Donohue et al., 2003) or qualitative as in providing a written narrative for later dimensional coding (Estacion et al., 2004).

In the present study, six children, two each with SLI, SWMI, or Mixed impairments were observed in their regular classroom environment along with an individually paired typically developing classmate. Based on findings that many children with high-incidence exceptionalities (i.e. specific learning disabilities, mild intellectual disabilities, attention deficit hyperactivity disorder, and emotional disorders) require additional supports to satisfy teacher and classroom expectations for appropriate behavior (Lane et al., 2006), it was hypothesized that all of the children with impairments in the present study would exhibit more problematic behaviors in the classroom than their typically developing classmate. Teachers were also asked to complete questionnaires concerning the communication, working memory, and attention skills of the participants. It was anticipated that all children with impairments would be judged to have greater difficulty in all three of these areas. We were particularly interested in whether the specific difficulties described by observers and teachers would be uniquely associated with the underlying deficit in language, working memory, or both. Findings that children with language impairment have more difficulty with language-related behaviors such as 'leaves words out' while those with working memory impairment with

Table 1 Standardized test results for participants with impairments

Pair number	Profile	Age (years;months)	CLS	VWMC	VSPWMC	TONI-3
1	SLI	8;11	82	92	113	115
2	SLI	9;6	84	108	119	95
3	SWMI	8;8	97	83	75	89
4	SWMI	7;11	90	75	80	100
5	Mixed	8;8	84	75	83	97
6	Mixed	8;3	82	75	75	104

Notes: CLS = Composite Language Score of CELF-IV; VWMC = verbal working memory composite of AWMA; VSPWMC = visuospatial working memory composite of AWMA; TONI = Test of Nonverbal Intelligence.

memory-related behaviors such as 'loses place in lesson' would provide strong evidence of observable differences between SLI and SWMI. Equivocal findings, on the other hand, may indicate that difficulties exhibited by these children are similar despite different underlying core deficits.

II Methods

1 Participants

Six pairs of children participated in the present study, each pair consisting of one child with an impairment and one typically-developing peer in the same classroom. Two each of the children with impairment were previously identified as having SLI, SWMI, or Mixed language and working memory impairments. The mean age of the 12 participants (7 boys, 5 girls) was 8;8 years, i.e. 8 years and 8 months (*SD* = 0.69; *Range* = 7;11 to 9;7). All of the children were attending a government-funded public school in a mainstream classroom of approximately 25 students; four were in third grade (8;0–8;11), and one pair each were in second grade (7;0–7;11) (impairment profile = SWMI-4) and fourth grade (9;0–9;11) (impairment profile = SLI-2). All of the pairs were same sex except for the second grade pair.

a Participants with impairments: All of the children with impairments were selected from those identified in Archibald and Joanisse (2009). The children with SLI scored more than 1 *SD* below the standardized mean on the Composite Language Score (CLS) of the Clinical Evaluation of Language Fundamentals, 4th edition (CELF-4; Semel et al., 2003), but scored within 1 SD of the standardized mean on both the verbal working memory composite (VWMC) and visuospatial working memory composite (VSPWMC) of the Automated Working Memory Assessment (AWMA; Alloway, 2007). The children with SWMI had the opposite profile scoring more than 1 *SD* below the standardized mean on both the VWMC and VSPWMC of the AWMA and within 1 *SD* on the CLS. Those with Mixed impairments scored more than 1 *SD* below the mean on the VWMC, VSPWMC, and CLS. Standard scores for the CLS, VWMC, VSPWMC are presented in Table 1 for the participants with impairments. Scores from the Test of Nonverbal Intelligence 3 (TONI-3; Brown et al., 1997) administered for descriptive rather than identification purposes are presented in Table 1 as well. Notably, all participants achieved non-verbal intelligence scores in the average range for their age. At the time of the present study, a school official other than the child's teacher but familiar with the child (e.g. special education teacher) confirmed that each participant had ongoing learning difficulties.

b Typically developing children: Whenever possible (n = 3) a typically-developing child was recruited from our database who had scored in the average range on our screening measure (Archibald and Joanisse, 2009) and was currently in the same classroom as one of our participants

with impairment. For the remaining participants, a school official other than the classroom teacher (e.g. special education teacher) recruited from the relevant classroom a child considered to be typically developing in all areas including academic, motoric, and social.

2 Procedures

Each participant pair was observed by a trained research assistant in his or her classroom during three language-related instructional periods (approximately 50 minutes) and three numeracy-related instructional periods within a two-month period. The trained observer was blinded to the profile of the participant and the purpose of the study. Additionally, the classroom teacher ($n = 5$; two pairs, one with an impairment profile of SLI-1 and one with Mixed-6, were in the same classroom) completed three questionnaires for each participant: the children's communication checklist (Bishop, 1998), the working memory rating scale (Alloway et al., 2008), and the Conners' teacher rating scale (Conners, 1997). Classroom teachers were also unaware of the purpose of the study or our designated profile of the participant.

a Classroom observation: The trained observer completed the observation record developed for the study (Appendix 1) at each observation session. The record was based on our previous work (Edmunds, 1999; Edmunds and Blair, 1999) with additional items added for the present study based on relevant clinical knowledge concerning children with language, memory, or attention difficulties. Behaviors were counted in three main categories:

- assigned work, e.g. follows part of instructions;
- communicating with others, e.g. speaks while others are speaking; or
- attention and behavior, e.g. receives reprimand from teacher.

The record provided side-by-side tracking of each member of the participant pair during the observation. Behaviors were noted by placing a number in sequence beside the observed behavior under the relevant participant. Observers could then write the respective number at the bottom of the record and provide a written narrative to elaborate, explain, or add detail. A new record sheet was started at each significant change in activity during the observation session. At the end of the observation session, the observer completed an observer comments form, which provided a place for the observers to provide their own thoughts about the observation. Having a specific place for such comments helps to keep subjective opinions out of the observation record (Estacion et al., 2004).

There were two trained observers: one graduate student in speech–language pathology and one retired elementary school teacher. Training involved a meeting with the first author to discuss the observation record and comments form. Each item on the record was discussed to generate consensus on relevant criteria. Some of the criteria had clear operational definitions (e.g. incorrect response to question) while others required more interpretation (e.g. inattentive, but not disruptive). For the latter, overt signs necessary to consider the behavior present were discussed. For example, children were considered inattentive if they required an alerting signal from a teacher or peer to respond, or spent prolonged periods looking away from the lesson focus. The two observers and first author observed a classroom not selected in the present study for 10-minute intervals. After each interval, we met to review our observations and reach consensus on coding and important comments. An inter-rater reliability for counting problematic behaviors of 0.7 was achieved.

b Teacher questionnaires: The Children's Communication Checklist (CCC; Bishop, 1998) measures various aspects of communicative impairments with a concentration on pragmatic (social communication) skills. The CCC contains 70 items that are grouped in 9 scales:

a) speech output;
b) syntax;
c) inappropriate initiation;
d) coherence;
e) stereotyped conversation;
f) use of conversational context;
g) conversational rapport;
h) social relationship; and
i) interests.

The sum of scales (c) to (g) reflects an overall measure of pragmatic skills, the Pragmatic Composite Score. Items are scored on a three-point scale (0 = does not apply, 1 = applies somewhat, 2 = definitely applies, and unable to judge/missing value). Most of the items are formulated negatively but some are formulated positively. The lower the score on the CCC, the more impaired the child is. Scores are compared to clinical cut-offs provided by Bishop (1998).

The working memory rating scale (WMRS; Alloway et al., 2008) consists of 20 short descriptions of problem behaviors (e.g. 'Mixes up material inappropriately') that differentiate children with low and average working memory abilities (Alloway et al., 2009). Teachers rate how typical each behavior is of the child on a four-point scale (0 = not typical at all; 3 = very typical). All of the items are formulated negatively. Scores are converted to standard T scores ($M = 50$; $SD = 10$) with higher scores reflecting more memory difficulties.

The Conners Teacher Rating Scale (CTRS; Conners, 1997) is a rating scale of childhood behavior disorders that effectively distinguishes children with Attention Deficit Hyperactivity Disorder (ADHD)-type behavior from typically developing children (Abikoff and Gittelman, 1985; Conners, 1997). The CTRS has 28 items that provide four subscale measures:

1. oppositional;
2. cognitive problems;
3. hyperactivity; and
4. ADHD index.

Items are scored on a four-point scale (0 = no problem; 3 = problem highly likely). All of the items are formulated negatively. Scores are converted to standard T scores ($M = 50$; $SD = 10$) with higher scores reflecting more problematic behaviors.

3 Data analysis

We provide descriptive statistics of the quantitative data together with results from paired-sample Wilcoxon Signed Rank tests (Z-statistic) where appropriate. For the qualitative data, we asked six graduate students in speech–language pathology to rate unique comments made by the observers on an equal interval 5-point scale related to whether the problem or demands of the situation tasked language or memory (i.e. definitely language, mostly language, mostly memory, definitely memory, or neither language or memory). Beyond provision of the anchor points, no further criteria for

Table 2 Number of occurrences of observed problematic classroom behaviours for each participant

Pair	Profile	Assigned work	Communicating with others	Attention and behaviour	Total
1	SLI	11	2	28	41
	TD-match	0	2	5	7
2	SLI	18	2	31	51
	TD-match	10	0	17	27
3	SWMI	10	9	16	35
	TD-match	5	5	10	20
4	SWMI	15	5	43	63
	TD-match	0	0	3	3
5	Mixed	10	1	6	17
	TD-match	1	0	3	4
6	Mixed	21	1	29	51
	TD-match	5	0	5	10

these ratings were provided although all of the raters were familiar with our previous work (Archibald and Joanisse, 2009). The raters also provided ratings on the same scale for each of the descriptors included in our three teacher questionnaires.

III Results

Table 2 provides a summary of the frequency counts for observed classroom behaviors for each participant in each of the three categories of assigned work, communicating with others, and attention and behavior, as well as overall. Observations related to communicating with others were significantly less common than observations related to either assigned work ($Z = 2.502$, $p = .012$) or attention and behavior ($Z = 2.669$, $p = .008$) overall. This pattern was true for 10 of the 12 participants (exceptions: TD-1, TD-3). Thus, problematic behaviors were more likely to be related to completing and attending to school work than communicating. Ranges in the number of problem behaviors observed amongst the children with impairments were overlapping such that one child with each atypical profile was observed to have the most difficulties in assigned work (Mixed-6, 21; SLI-2, 18; SWMI-4, 15) and in attention and behavior (SWMI-4, 43; Mixed-6, 29; SLI-2, 31). Surprisingly, difficulties communicating with others were observed most frequently in the two children with SWMI (SWMI-3, 9; SWMI-4, 5) whereas none of the remaining participants had more than 2 occurrences of such behavior. As expected, frequency counts were greater for children with impairments relative to typically developing classmates (Assigned work, $Z = 2.201$, $p = .028$; Communicating with others, $Z = 2.032$, $p = .042$; Attention and behavior, $Z = 2.201$, $p = .028$). Individual pair patterns were consistent with these results (exception: Pair 1, communicating with others was equivocal).

A total of 805 comments were written by the trained observers on the observation records, of which many were equivalent such as ‘talking to neighbor’ and ‘talking to other students’. A trained research assistant otherwise uninvolved in the study and unfamiliar with its purpose transcribed all of the comments and noted equivalencies, which resulted in a pool of 121 unique comments. The

Table 3 Number of language- and memory-related comments and proportions for each participant

Pair	Profile	Observer comments			Percentage of language/ memory of total	Profile	Observer Comments			Percentage of language/ memory of total
			Related to					Related to		
		Total	Language	Memory			Total	Language	Memory	
1	SLI	53	19	2	36/4	TD-match	29	16	3	55/10
2	SLI	82	32	11	41/13	TD-match	11	1	3	9/27
3	SWMI	120	59	15	49/13	TD-match	6	1	0	17/0
4	SWMI	114	61	16	54/14	TD-match	0	0	0	n/a
5	Mixed	73	43	6	60/8	TD-match	16	2	1	13/6
6	Mixed	116	42	7	36/6	TD-match	29	8	7	28/24

graduate student raters rated each comment, and comments judged by four or more of the raters to be 'neither language or memory' ($n = 15$; e.g. 'not able to focus during activities') were removed from the pool. Ratings of 'definitely language' and 'mostly language' were given scores of 1 or 2, respectively, and ratings of 'definitely memory' and 'mostly memory', 3 or 4. A mean rating was then calculated for each comment. A mean of 2.5 reflects the midpoint on our 1 (definitely language) to 4 (definitely memory) scale with values less than 2.3 reflecting language-related comments (a majority of ratings in the 1 or 2 range) and values above 2.7 reflecting memory-related comments (majority ratings of 3 or 4). Examples of language-related comments include '[The student needed] help to spell a word', 'Asked neighbor to define one of the words on worksheet', and 'Did not follow along in cooperative reading'. Examples of memory-related comments include '[The student] labeled only part of diagram', '[The student] forgot to bring materials to carpet', and '[The teacher] frequently checked with the student to ensure he was on the right track.'

The number of language- or memory-related and total comments written for each participant are presented in Table 3 along with the proportion of language- or memory-related comments to total comments. More language-related ($n = 62$) than memory-related ($n = 16$) comments were made overall. This pattern was true for all participants ($Z = 2.584$, $p = .01$) with only one exception (TD-2). Thus, more classroom difficulties were described as language rather than memory problems for all children regardless of the child's underlying deficits. Overall, significantly more language-related ($Z = 2.201$, $p = .028$) and total ($Z = 2.207$, $p = .027$) but not memory-related ($Z = 0.734$, $p = .46$) comments were made about the impaired than typically developing children. The percentage of language-related comments was highest for one child with Mixed impairments (Mixed-5, 60%) and the two children with SWMI (SWMI-3, 54%; SWMI-4, 49%). Thus, 3 of the 4 children with working memory impairments had higher percentages of language-related comments than the children with SLI (SLI-1, 36%; SLI-2, 41%). The percentage of memory-related comments was highest for the two children with SWMI (SWMI-3, 13%; SWMI-4, 14%) and one child with SLI (SLI-2, 14%). Thus, 3 of the 4 children with language impairments (SLI-1, 4%; Mixed-5, 8%; Mixed-6, 6%) had lower percentages of memory-related comments than the children with SWMI.

To summarize, the children with SLI, SWMI, and Mixed impairments experienced difficulties with assigned work and attention and behavior at similar levels in the classroom. Communicating with others was less problematic overall, and was observed most commonly in the children with SWMI. More of the behaviors were attributed to language than memory factors overall. Language-related comments comprised a higher percentage of the total comments for the majority of children with working memory impairments (regardless of language status) and memory-related comments

Table 4 Teacher questionnaire results for each pair

Questionnaire/Subscale	SLI	TD-match	SWMI	TD-match	Mixed	TD-match
		Pair 1 Pair 2		Pair 3 Pair 4		Pair 5 Pair 6
Children's Communication Checklist (Raw score):						
• Speech Output	35	32	33	36	34	32
	28	35	26	30	33	34
• Syntax	32	30	31	31	32	32
	29	32	32	32	30	32
• Inappropriate initiation	29	29	23*	27	29	28
	29	24*	30	30	30	28
• Coherence	29	36	27	34	34	35
	17*	36	32	36	29	36
• Stereotyped conversation	28	29	20*	28	30	30
	29	28	27	30	29	29
• Use of conversational context	25	31	24*	29	29	30
	27	29	30	32	25	32
• Conversational rapport	32	34	27	33	31	34
	29	34	26*	34	29	34
• Social relationship	31	34	30	33	28	34
	32	34	30	34	31	34
• Interests	30	29	30	29	30	32
	34	31	23*	28*	32	30
• Pragmatic composite	143	159	121*	151	153	157
	141	151	198	224	142	159
Working Memory Rating Scale	70	41	63	44	58	42
(T-score)	68	42	46	41	75*	41
Conners' Teacher Rating Scale (T-score):						
• Oppositional	49	45	81*	47	58	47
	45	45	45	47	53	45
• Cognitive problems	59	42	74*	46	77*	49
	68	42	44	44	69	42
• Hyperactivity	46	42	65	45	45	45
	49	42	43	45	73*	43
• ADHD Index	58	41	74*	44	61	42
	62	42	43	44	71*	41
Derived Scores: Mean (Standard Deviation):						
• Language-related items	3.3 (4.0)	2.0 (3.9)	5.6 (3.7)	2.5 (4.1)	2.9 (4.3)	1.5 (3.5)
	4.5 (4.3)	2.2 (3.9)	3.0 (3.9)	1.8 (3.8)	3.7 (4.1)	1.8 (3.8)
• Memory-related items	6.4 (3.8)	0.3 (1.3)	5.3 (2.1)	1.2 (2.2)	4.4 (4.5)	0.4 (1.9)
	5.9 (2.2)	1.1 (2.7)	1.1 (1.5)	0.3 (1.3)	7.6 (2.8)	0.4 (1.9)

Note: * = scores falling in the deficit range based on questionnaire cut-offs

comprised a lower percentage of total comments for the majority of children with language impairment (regardless of working memory status).

Results of the teacher questionnaires scored according to each questionnaire's instructions are provided in Table 4. None of the questionnaires as scored consistently identified the impaired groups. One child with SWMI (SWMI-3) showed a pattern of deficits on subscales of both the

Children's Communication Checklist (CCC) and the Conners Teacher Rating Scale (CTRS). Three of the four children with working memory impairments (SWMI-3, Mixed-5, Mixed-6) scored in the impaired range on at least one scale of the CTRS. Elevated scores on the working memory rating scale (WMRS) were noted for only one child with Mixed Impairments (Mixed-6). The children with SLI were not identified as having difficulty by these questionnaire results (with only one exception: CCC-coherence for one child with SLI).

One problem we anticipated in using these questionnaires is the considerable overlap between items across questionnaires, for example, the items 'not able to focus during activities' from the WMRS and 'short attention span' from the CTRS. We thus conducted an independent rating of the extent to which an item was related to language or memory difficulties. The graduate student raters rated each item from all three questionnaires ($n = 118$), and mean ratings were calculated as for the observer comments. We excluded from this analysis 18 items for which four or more raters gave a rating of 'neither language nor memory'. Mean ratings less than 2.3 were considered 'language-related items' ($n = 63$) and mean ratings above 2.7 were considered 'memory-related items' ($n = 23$). Examples of language-related items include 'Leaves off beginnings or ends of words', 'Tends to leave out words or grammatical endings', and 'Uses terms like "he" without making it clear what he/she is talking about'. Examples of memory-related items include 'Puts hand up to answer a question but forgets what he/she intended to say', 'Depends on neighbor to remind them of the current task', and 'Needs regular reminders of each step in a written task'. Within each domain (i.e. either language or memory), we then reassigned raters' scores on a 4-point unidimensional scale so that, for example for the language domain, 4 = definitely language to 1 = least language. Mean ratings for each item within domain were treated as weightings. Participant raw scores for each item were multiplied by the item weighting, and a mean score within each domain was derived for each participant. It should be noted that while the rating scales for the WMRS and CTRS were well-matched four-point scales (0 to 3), the CCC scores had to be modified for our purposes. For the CCC scale of 'does not apply', 'applies somewhat', and 'applies definitely', we considered the latter two ratings to correspond most closely to scores of 2 and 3 on the WMRS and CTRS. Thus, we assigned scores of 0 to 'does not apply responses', 2 'to applies somewhat', and 3 to 'applies definitely' for the negatively formulated items, and the reverse for positively formulated items.

The derived scores for language-related and memory-related items on the questionnaires are presented in Table 4. The derived score reflects the degree to which problems within a domain were associated with each participant. The impaired children had significantly higher scores in both the language ($Z = 2.021$, $p = .028$) and memory domains ($Z = 2.021$, $p = .028$) than the typically developing participants. For the typically developing children, language scores were higher than memory scores in all cases. An interesting pattern emerged for the impaired children. The two children with SWMI had higher scores on language- than memory-related items (SWMI-3, 5.6 vs. 5.3; SWMI-4, 3.0 vs. 1.1) whereas the children with a language impairment (SLI or Mixed) had higher scores on the memory- compared to language-related demands (SLI-1, 6.4 vs. 3.3; SLI-2, 5.9 vs. 4.5; Mixed-5, 4.4 vs. 2.9; Mixed-6, 7.7 vs. 3.6).

One final aspect of the teacher questionnaire results to be considered are the questions related to reading, spelling and math problems on the CTRS. Although we collected no direct measures of academic performance, the teacher ratings give some indication of literacy and numeracy competency. The questionnaires were completed within the last three months of the school year, a time when the teacher is in an excellent position to judge academic progress. Table 5 provides the teacher ratings for problems in reading, spelling, and arithmetic for each participant. All of the participants with impairments were judged as somewhat likely, likely or highly likely to have difficulties in reading, spelling, and arithmetic except one child with SWMI (SWMI-4). All of the

Table 5 Teacher reading, spelling, and arithmetic ratings for each participant

Pair	Profile	Reading	Spelling	Arithmetic
1	SLI	2	1	2
	TD-match	0	0	0
2	SLI	2	3	2
	TD-match	0	0	0
3	SWMI	2	3	2
	TD-match	0	0	0
4	SWMI	0	0	0
	TD-match	0	0	0
5	Mixed	3	3	3
	TD-match	1	1	0
6	Mixed	3	2	3
	TD-match	0	0	0

Notes: Scores taken from the Conners Teacher Rating Scale (1997) for items pertaining to reading, spelling, and arithmetic. Items are scored on a four-point scale (0 = no problem; 3 = problem highly likely).

typically developing children were judged as unlikely to have problems in these areas, except for one child (TD-5) who was judged as being somewhat likely to have difficulty in reading and math.

IV Discussion

The purpose of the present small-scale study was to provide a description of the school behaviors of children with specific language impairment (SLI), specific working memory impairment (SWMI), or both language and working memory impairments (Mixed). All of the children with impairments except one with SWMI had reading, spelling, and arithmetic difficulties by teacher report. Children of all atypical profiles exhibited similarly frequent problematic behaviors requiring more assistance with assigned work and experiencing more difficulty maintaining attention and acceptable classroom behavior than typically developing classmates. More of the observed classroom difficulties were attributed to language- than memory-related difficulties for all participants. Working memory impairment was associated with a high percentage of language-related explanatory comments, whereas language impairment was associated with a low percentage of memory-related comments. The teacher questionnaires for communication, working memory, and attention largely failed to consistently identify participants when scored according to the published instructions, although teachers generally rated the impaired children more severely. The majority of the participants with working memory impairments scored in the deficit range on one subscale of the teacher rating scale for attention, but the subscale varied. When item ratings of language- or memory-related demands were considered, scores were higher on the memory-related than on the language-related items for the children with language impairment and on the language- than memory-related items for the children with SWMI.

The results of this study are suggestive of difficulties in the realm of school behaviors for children with SLI, SWMI, and Mixed impairments. These children required more teacher assistance and behavior management than their typically developing classmates. As well, academic learning difficulties were common. These results represent a small contribution to the considerable evidence of lower school success in children with SLI (e.g. Arvedson, 2002; Catts et al., 2002; Bishop and Clarkson, 2003). More importantly, however, the findings provide some of the first evidence of school challenges for children with working memory impairment defined by cross-domain deficits in immediate storage plus processing complex span tasks. Interestingly, not all of the children with

working memory impairment had reading, writing, and arithmetic problems: one did not. However, all of the children with working memory impairment did exhibit more problematic classroom behaviors than their typically developing classmate. These findings are consistent with reports of poor academic achievement in children with learning disabilities known to have working memory difficulties (Swanson, 1993, 2004).

Despite the observed difficulties experienced by these children, there were relatively few patterns that distinguished the children with SLI, SWMI, and Mixed impairments. Generally, these groups exhibited similar frequencies of classroom problems, and were rated similarly on teacher checklists. An important implication of this finding is that while students with the described difficulties can appear very similar on the surface, they may be struggling with classroom expectations for different reasons. While the teachers and observers successfully identified all of the children with impairments relative to their typically developing classmates, observations and ratings of difficulties did not correspond to the child's underlying deficit generally.

More specific analyses of the comments and questionnaire items based on independent ratings of language- or memory-relatedness provided some interesting findings. Children with working memory impairments appeared to have some difficulty with language/communication even when they did not have a language impairment according to standardized test results. For example, children with SWMI had the highest frequency of problematic classroom behaviors related to communicating with others, and had higher teacher ratings on language- than memory-related questionnaire items. As well, both children with SWMI and one child with Mixed impairments had the highest proportion of language-related observer comments. These results provide preliminary and tentative evidence that a working memory limitation may negatively impact a child's ability to manage at least some of the language demands posed by classroom activities. It is well recognized that many language tasks place high demands on working memory (Baddeley, 2003). As a result, children with working memory impairments may fail language tasks if such tasks exceed their working memory capacity.

Children with language impairment, on the other hand, had a somewhat different pattern. As might be expected, children with language impairment had lower percentages of memory-related observer comments consistent with their core language deficit (compare Leonard, 1998). In contrast, however, these children also had very few observed problematic behaviors related to communicating with others and had higher teacher rating scores on the memory- than language-related questionnaire items. The lack of observed difficulties in communicating with others may be related to our measurement tool. Our communicating with others category included only eight items and may have had insufficient scope to capture the difficulties experienced by our children with relatively mild language impairments. The pattern of teacher ratings for our children with language impairments is more puzzling. It is unclear why these children should be rated more highly on memory- than language-related items, a pattern that was not seen in any of the typically developing children. At minimum, these results suggest that teachers may not solely attribute the difficulties experienced by children with language impairment to language deficits; however, further investigation of this finding is warranted.

It is interesting that the children with Mixed language and working memory impairments were not distinguished by number or degree of difficulties in the present study. The scores of the children with Mixed impairments were similar in range to those of the children with SLI or SWMI. It seems that having a double deficit – in both language and working memory – did not yield an additive effect that 'doubled their difficulties'. The children with Mixed impairments showed patterns similar to those of children with SLI. Both children with SLI and Mixed impairments (i.e. with language impairments regardless of working memory status) had fewer memory-related observer comments, and had higher memory- than language-related scores on questionnaire items. These results may suggest that a child's language status has a determining impact on school behaviors.

There are several limitations to the present study. First and foremost, it is a preliminary study involving few participants in total, and only two with each of the atypical profiles being explored. As well, the children's impairments were relatively mild with standardized scores ranging from 1 to 1.3 *SD* below the mean. Although all of the participants with impairments were identified by school personnel as requiring extra assistance in school, not all of these children were receiving assistance beyond classroom modifications. As a result, it is unclear how the children with impairments in this study compare to children receiving clinical services. It may be that clearer patterns would have emerged had children with more severe impairments been included in the present study. As well, the methods employed in the current work were somewhat limiting. We chose three teacher questionnaires in common use that tapped a broad range of communication, memory, and attention behaviors. However none of these questionnaires has been found to discriminate SLI and SWMI groups, and thus may not have been the best choice for identifying distinct profile patterns. As well, our checklist approach to classroom observation provided for rapid coding of similar behaviors across participants but may have constrained our observers' reporting. Nevertheless, the preliminary evidence reported in the present study provides the impetus for further study. A larger scale qualitative study is needed potentially employing Grounded Theory (Corbin and Strauss, 2008) to develop a theoretical framework of the real world impact of developmental language and working memory impairments.

The present findings have implications for teaching children with language and/or working memory impairments. Teachers will need to specifically design and implement classroom activities, both academic and behavioral, to accommodate for the described language and working memory deficits. In keeping with the fundamental principles of inclusive education, this will have to be done on a child-specific basis dependent on the identified deficit area (Edmunds and Edmunds, 2008). At the same time, however, there does appear to be some overlap in the respective deficit profiles that would allow teachers to generate similar but not identical sets of academic and behavioral classroom activities. In this manner, the individual needs of each student can be met without teachers facing the onerous task of designing and implementing a completely different intervention for each individual student.

Children with language and/or working memory impairments in the present study who struggled to similar extents with completing assigned work and maintaining attention in the classroom were rated similarly on teacher checklists, and were usually considered at risk academically. More detailed analyses revealed difficulties spanning both language and memory for all of the atypical children regardless of their language or memory status. Children with memory impairments had some classroom difficulties related to communication/language and, conversely, the children with language impairments had higher teacher ratings on memory-related items. Interestingly, there was no evidence that impairments in both language and working memory may have an additive effect on school behaviors. Children with Mixed language and working memory impairments showed similar frequencies and patterns of comments and ratings to the other children with impairments, and to the children with SLI in particular. It is clear that these tentative findings of specific and cross-domain impacts of developmental language and working memory impairments on school learning warrant further investigation.

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Appendix 1 Observation record

Observation Record For Child #1 and Child #2 Time: _____ Sheet #: ___

Date of Observation: ____/____/____ Teacher: _____ School: _____Observer: _____
Lesson observed: □ **Language Arts** □ **Math** □ **Other:** _____ Activity (circle one): 1 2 3 4 5 6

Child's unique identifier:				Child's unique identifier:			
Child is working: □ individually □ in a pair □ with a small group □ with whole class				Child is working: □ individually □ in a pair □ with a small group □ with whole class			
Assigned work				**Assigned work**			
Ignores instructions				Ignores instructions			
Follows part of instructions				Follows part of instructions			
Attempts instructions incorrectly				Attempts instructions incorrectly			
Does not begin task				Does not begin task			
Requests repetition				Requests repetition			
Loses place in lesson				Loses place in lesson			
Loses items necessary for work				Loses items necessary for work			
Makes careless mistakes				Makes careless mistakes			
Receives assistance from teacher				Receives assistance from teacher			
Receives assistance from a student				Receives assistance from a student			
Communicating with others				**Communicating with others**			
Leaves words or sounds out when talks				Leaves words or sounds out when talks			
Difficulty being understood by others				Difficulty being understood by others			
Incorrect response to question				Incorrect response to question			
Inadequate response to question				Inadequate response to question			
Speaks while others are talking				Speaks while others are talking			
Makes off topic remark				Makes off topic remark			
No eye contact when spoken to				No eye contact when spoken to			
Does not wait for speaking turn				Does not wait for speaking turn			
Attention and Behaviour				**Attention and Behaviour**			
Inattentive (but not disruptive)				Inattentive (but not disruptive)			
Distracted by event extraneous to lesson				Distracted by event extraneous to lesson			
Restless (squirmy, fidgeting)				Restless (squirmy, fidgeting)			
Distracts other children				Distracts other children			
Off task behaviour (specify)				Off task behaviour (specify)			
Receives reprimand from teacher				Receives reprimand from teacher			
Does not join other children				Does not join other children			
Does not wait for turn in activity				Does not wait for turn in activity			
Interrupts or intrudes on others				Interrupts or intrudes on others			

Contextual information (note any exceptional circumstances or events):