Journal of Child Psychology and Psychiatry 47:2 (2006), pp 176–189 doi:10.1111/j.1469-7610.2005.01454.x

Towards a typology of specific language impairment

Marjolijn van Weerdenburg, Ludo Verhoeven, and Hans van Balkom
Radboud University Nijmegen, The Netherlands

Background: The population of children with specific language impairments (SLI) is heterogeneous. The present study was conducted to examine this heterogeneity more closely, by identifying and describing subgroups within the population of children with SLI in the Netherlands. **Method:** A broad battery of language tests and language-related cognitive tests were administered to 147 six-year-old and 136 eight-year-old children with SLI. **Results:** Factor analyses revealed 4 factors indicating 4 distinctive linguistic domains for both age samples: 1) lexical-semantic abilities, 2) auditory conceptualization, 3) verbal sequential memory and 4) speech production. These empirical findings were further validated by the positive correlations found between the language factors and the judgments of teachers and speech therapists. Finally, a cluster analysis revealed 4 distinct clusters of SLI children for each sample with specific language profiles based on the 4 factors. Results were nearly the same for both age samples. **Conclusions:** The language problems that emerged from the two samples of children with SLI could be described as falling into four types. Based on these language types, four subgroups of children with SLI could be distinguished, each with a specific profile. Some subgroups had severe problems on one specific type of language problem; others had severe problems in more than one type of language problem when compared to the other subgroups of the same age sample. The different profiles may indicate that a more dynamic approach is needed in intervention, considering the presence of both compensating and restricting factors within each child with SLI. **Keywords:** Specific language impairment, lexical-semantic abilities, auditory conceptualization, verbal sequential memory, speech production, classification.

Children with specific language impairment (SLI) show a delayed development in language comprehension and/or production with an unknown etiology. This diagnosis is assigned on the basis of exclusion: the child shows no hearing loss, no emotional disorders, and no mental retardation. Nevertheless, it is generally agreed that the label applies to a very heterogeneous group of children (Aram, Morris, & Hall, 1993; Bishop, 1997; Leonard, 1998; Stark & Tallal, 1981). Several studies have examined the complex nature of SLI in an attempt to further classify the nature of the impairment, and these findings will be considered in greater detail below.

In an extensive review of the SLI literature from earlier decades, Bishop (1992) mentions six hypotheses that might be important for understanding and maybe even explaining the specificity of the language difficulties encountered by children showing SLI. First, the process of converting underlying knowledge into a speech signal may be impaired and thereby result in speech output problems. Second, auditory perception may be impaired and thereby the course of language acquisition. Third, the specialized linguistic mechanisms responsible for the use of morpho-syntactic knowledge may be impaired. Fourth, language processing may be affected by a deficit in conceptual development. The last two hypotheses involve a broader cognitive view of the underlying problems, e.g., that there may be a failure to apply the appropriate hypothesis-testing procedures during the language-learning process or a more general limitation in the speed and capacity of the child's information-processing system. Bishop (1992) reports empirical evidence for all six hypotheses, but she also mentions that some of the results appear to be contradictory and that two major methodological problems exist: the heterogeneity of SLI and the problem of distinguishing cause and effect in correlational studies. Furthermore, the hypotheses are related to potential causes of language impairment and a one-on-one relation between the hypothesized causes and types of language disorders cannot be made.

More recently, Bishop (2004) has described four subtypes of developmental speech and language impairment. The first and most common or 'Grammatical SLI' group is, according to Bishop, the group characterized by a disproportionate number of problems with grammatical development, sometimes accompanied by major lexical-semantic problems and some limitations on their nonverbal abilities. The second group is characterized by severe receptive language disorders and sometimes referred to as a childhood manifestation of verbal auditory agnosia. The third group is characterized by speech output problems, and the fourth group consists of children with pragmatic language impairment (i.e., problems in using language appropriately in a given context). However, although Bishop (2004) states that there is at least some broad agreement among clinicians on these four subtypes of language problems, there is as yet no real empirical evidence to

Published by Blackwell Publishing, 9600 Garsington Road, Oxford OX4 2DQ, UK and 350 Main Street, Malden, MA 02148, USA

substantiate this division into four distinct groups of children with SLI.

Classification studies

Earlier studies have made an attempt to provide empirical evidence for classifying SLI. In a number of studies *test scores* have been used to classify language impairments empirically. An example is the study by Beitchman et al. (1989) who investigated a group of children from a larger sample of 5-year-old English-speaking kindergarten children. First, the children's language, auditory comprehension, auditory memory and articulation were tested. Children scoring below certain cut-off points were then classified as 'speech-language impaired'. Second, a cluster analysis was conducted not only on the data from the 'speech-language impaired' children but also on the data from the children who passed the screening stage (total $N = 348$). The authors then distinguished a 'high overall' group, a 'poor auditory comprehension' group, a 'poor articulation' group, and a 'low overall' group. Given the mixed nature of the group of children included in the cluster analysis, however, this classification cannot be seen as a classification of specific language impairments.

In other studies, *clinical judgments* have been taken as the basis for the classification of language impairments. Miller (1987), for example, composed a list of clinical subtypes using the judgments of 30 speech-language clinicians asked to categorize language disorders on the basis of their experience. The following behavioral categories were then taken to indicate distinct types of language disorder: sentence formulation problems, word finding problems, rate and fluency problems, hyperverbosity, pragmatic or discourse problems and, finally, semantic and referencing deficits.

Another classification system based on clinical observations of linguistic characteristics is Rapin and Allen's nosology (Rapin & Allen, 1983; Rapin, 1996). It contains three subtypes of developmental language disorders: mixed receptive-expressive disorders (including verbal 'auditory agnosia' and a 'phonologic-syntactic deficit disorder'), expressive disorders (including 'verbal dyspraxia' and a 'speech programming deficit disorder'), and higher-order processing disorders (including a 'lexical deficit disorder' and a 'semantic-pragmatic deficit disorder'). This classification system was initially formulated for young non-autistic language-disordered children, but further investigation revealed that the language disorders could also be identified in preschoolers on the autistic spectrum (with the exception of expressive deficits) (Allen & Rapin, 1992).

Finally, Bishop (1998) developed an instrument based on clinical observation using the Children's Communication Checklist (CCC). This questionnaire was designed to assess pragmatic aspects of communication as observed by the child's teacher and to distinguish subgroups of children within the language-impaired population. Results showed that a subgroup of children with pragmatic language impairment (PLI) was identified that could be differentiated from children with more typical forms of SLI (where the principal problems are with language structure) and from children with autistic disorders (Bishop & Baird, 2001; Bishop & Norbury, 2002).

A number of researchers have gathered both *test scores* and *clinical judgments* to classify language impairments. However, there are many differences in the ways in which they combined the different types of information. Wilson and Risucci (1986), for example, had clinicians examine the test profiles for 93 preschoolers with a developmental language disorder and assign the children to subtypes on the basis of the test scores, which addressed mainly the auditory and visual abilities of the children. The outcome was a total of 11 categories but, owing to the small numbers of children in some of the categories, two were omitted and the remaining nine collapsed into five: 'expressive', 'receptive', 'memory and retrieval', 'global', and 'no deficits'. In order to gain insight into the validity of the five categories, two procedures were carried out. First, a cluster analysis was conducted on the test results for 12 of the 30 original auditory and visual tests. Second, the major categories formed by the clinicians were compared on a number of variables *not* used for classification purpose (i.e., the results for 6 of the 30 original tests). According to the authors, both procedures provided support for the validity of the five categories generated by the clinical interpretation of quantitative data.

Another example of having clinicians use quantitative test scores to classify children is a study by Haynes and Naidoo (1991) who administered a battery of language, speech, and auditory tests to 156 language-impaired children between 5 and 13 years of age. The battery of tests administered to examine the scope of the linguistic abilities of the children was not uniform across the children. In order to classify the abilities of the children, the authors used both the test scores and staff reports regarding the linguistic abilities of the children. Grouping the children in terms of their 'intuitions' regarding the different possible subgroups of language impairment, nine specific subtypes of language impairment were identified: 'speech', 'speech plus', 'classic', 'semantic', 'residual', 'moderate', 'no language', 'young unclassified', and 'severe'.

Finally, a study by Conti-Ramsden, Crutchley, and Botting (1997) can be mentioned as yet another example of research that combines clinical and test score information. To start with, the authors administered a battery of tests to 242 seven-year-old children with language impairments in order to evaluate the children's grammar, vocabulary,

expressive competence, reading, number skills, and general nonverbal abilities. They then interviewed the teachers and speech-language therapists with regard to the children's impairments in the domains of articulation, phonology, syntax and/or morphology, semantics and/or pragmatics and whether the problems were 'expressive only,' 'expressive and receptive,' or 'mostly receptive'. Following this, a cluster analysis was conducted on the children's test scores and was found to produce six groups of children. Chi-square analyses were then undertaken to determine whether children with particular difficulties, according to the teachers, were statistically more likely to fall into one or the other subgroup. By combining the results of the cluster analysis with the results of the chi-square analyses, each cluster was finalized and a similarity between the cluster characteristics and the clinical classification of developmental language disorders put forth by Rapin and Allen (1987) was found.

Some critical comments

Several comments can be made with respect to these earlier investigations. First, the assessment batteries often appear to be incomplete or too 'limited'. It is known that several language domains are important in playing a role in either the specific causes or the linguistic outcomes of SLI (Bishop, 1992; Leonard, 1998). Measurements of discourse and information processing abilities are typically missing, for example.

Second, populations on which the classifications are based differ across studies. In one study (Beitchman et al., 1989), children with normal language development were also included in the classification procedure, which resulted in an ambiguous classification system for the speech/language impaired. Even when only specific language impaired children are included in the analyses, the inclusion criteria also differ widely across the studies, which greatly complicates generalization to a larger group of language-impaired children. Besides this, data of children within a very large age range are sometimes analyzed to provide a classification system for all ages within that range (Haynes & Naidoo, 1991). It is, however, likely that different classification systems are appropriate for different age groups.

A third comment concerns methodological issues. In many studies, no appropriate statistical analyses are undertaken. Sometimes the classification is done on the basis of clinical experience or intuition without further external validation. Sometimes the subgroups are otherwise too small and therefore collapsed together with little or no theoretical justification. Furthermore, no serious attempts have been made to validate the subtypes identified on the basis of quantitative test scores. Conti-Ramsden et al. (1997) characterized their clusters of subjects on the basis of both test scores and clinical judgments, but state in a second study on the same sample (Botting, Conti-Ramsden, & Crutchley, 1997) that some but not all of the test results relate strongly to the opinions of the teachers and speech therapists. This means that the subgroups identified by these authors are formed on basis of two different sources of information and thus not entirely unambiguous.

Finally, a clear distinction between the language *problems* that can occur and the subgroups of SLI *children* has not been made in previous studies. That is, many papers use 'subtypes' for children rather than language problems, but the existence of different language problems does not automatically imply the existence of different subgroups of language-disordered children. More than one type of language problem may be present in children with SLI. In this study, the term 'types' will be used when we refer to different types of language problems and the term 'subgroups' will refer to groups of children. The question is whether a specific type or types of problem best characterize(s) the different subgroups of SLI children. What is needed for a complete and useful classification is an empirically based analysis of the different types of language problems that are found to occur in specific language impaired children. Therefore, the exact nature of the problems should be confirmed by clinical judgments and, ultimately, the severity of each language problem within each child should be evaluated. Only then is it possible to examine the language problem or set of problems associated with a particular subgroup of children with SLI and determine whether the definitions of distinct subgroups are justified or not.

The present study

In the present study, 6- and 8-year-olds receiving special education for children with specific language impairment in the Netherlands were assessed with a comprehensive test battery to evaluate all possible markers of speech-language impairment known from recent literature on SLI (Bishop, 1992; Bishop & Leonard, 2000; Leonard, 1998; Levelt, 1989; Verhoeven & van Balkom, 2004). The first aim was to use factor analysis to classify the speech-language problems of the 6- and 8-year-olds with SLI. With this technique, the construct validity of the measurements could be investigated. If two measures are supposedly alternative ways of measuring the same construct, then they should load on the same factor (Smithson, 2000). The factors can be seen as latent variables reflecting specific types of speech-language problems. The second aim was to investigate whether the underlying factors of speech-language problems were valid in terms of criterion validity. Therefore, the relation(s) between the identified factor(s) and clinical judgments of experts in the

field working with the children with SLI were investigated. If the two types of data clearly correlate, then criterion validation of the factors is provided. Finally, cluster analyses were undertaken to explore the linguistic profiles on the underlying latent variables of different subgroups of children with SLI. The term SLI is used for a heterogeneous group of children, and cluster analysis can be used as a tool to unravel the heterogeneity by finding subgroups that differ significantly from each other on the linguistic factors.

Method

Participants

All participants were diagnosed with specific language impairment by a multidisciplinary team of specialists containing a physician, a psychologist, special educators, and a speech therapist. A child was diagnosed with SLI when he or she had a severe language impairment that was not the direct result of global intellectual, sensory, motor, emotional, or physical impairments. The participants were either attending a special school for language- and hearing-impaired children (87%) or involved in a special language-remediation program within a mainstream school (13%). In the Netherlands, there are 30 special schools for language-impaired children and 29 of them participated in this study. Children with hearing problems (>30 dB hearing loss) and children with a nonverbal score below 2.4 on the Raven Colored Progressive Matrices (standardized $M = 5$, $SD = 2$; van Bon, 1986) were excluded from the present study. Children displaying severe behavioral problems during testing were also excluded. Parental consent was obtained for all children who participated.

The participants were derived from two subpopulations within the population of children with SLI attending special schools or involved in remediation programs for language- and hearing-impaired children. One sample was randomly selected from the subpopulation of children with SLI in the age between 6;0 and 6;10 years and the other sample was randomly selected from the subpopulation of children with SLI in the age between 8;0 and 8;10 years. In order to achieve representative nation-wide samples, the number of participants from each school was based on school size; the more children with SLI in the school or the remediation program, the larger the percentage of children from that particular school in the sample. The six-year-old sample consisted of 148 children with a mean age of 6;4 years ($SD = 2$ months) and contained 102 boys (69%) and 46 girls (31%). The eight-year-old sample consisted of 134 children with a mean age of 8;5 years ($SD = 2$ months) and contained 99 (74%) boys and 35 girls (26%). The gender percentages and the distribution of socio-economic backgrounds were representative of the population of 6- and 8-year-old children enrolled in education for the specifically language-impaired in the Netherlands. Both groups scored above the mean for their age group on the Raven-CPM (with a standardized $M = 5$ and $SD = 2$ of the norm group; van Bon, 1986). The 6-year-olds had a standard mean of 5.4 ($SD = 1.7$), and the 8-year-olds had a standard mean of 5.5 ($SD = 1.8$).

Materials

The participants were tested on a wide variety of language and language-related skills. In Table 1, the tests are categorized by the domain they measure: lexical abilities, auditory perception, morpho-syntax, articulation, information processing, and pragmatics. This categorization was based on recent literature on SLI (Bishop, 1992; Bishop & Leonard, 2000; Leonard, 1998, Levelt, 1989) and was necessary to be certain to have at least one test for every possible marker of speech-language impairment. The children's language proficiency was evaluated using the Dutch Language Proficiency Test for All Children (*Taaltoets Alle Kinderen*, TAK; Verhoeven & Vermeer, 2001), which is a standardized discrete-point test for the assessment of 4- to 10-year-olds and consists of nine subtests. The subtest of Productive Vocabulary from an earlier version of the Language Proficiency Test (Verhoeven & Vermeer, 1986) was also included in the test battery. All of the subtests have been shown to be reliable with Cronbach's alphas between .90 and .97. The verbal sequential memory of the children was measured using two tests from the Dutch version of the Kaufman ABC Word Order and Number Recall (Kaufman & Kaufman, 1983). In addition, a task for the rapid naming of simple pictures (Verhagen & Aarnoutse, 2000) and the Dutch version of the revised Lindamood Auditory Conceptualization (LAC-r) test for examining phonemic awareness (Lindamood & Lindamood, 1979) were administered. Furthermore, the dyspraxia tasks Word Repetition, Nonword Repetition and Phonological Contrasts (Maassen & van der Meulen, 2000) were added to expand the repertoire of words to be articulated. Finally, the Children's Communication Checklist (CCC) (Bishop, 1998) was completed by the child's teacher. This instrument was developed with the specific goal of distinguishing within the language-impaired population between those children who have pragmatic difficulties and those with more typical forms of SLI, where the principal problems are with language structure. The teacher was presented with 70 statements and had to choose among the following answers: 'definitely applies', 'applies somewhat', 'does not apply', or 'unable to judge'. Five scales, assessing inappropriate initiation, coherence, stereotyped language, use of context, and rapport were combined to form the pragmatic composite score (Bishop & Baird, 2001).

In order to obtain clinical judgments on several domains, a questionnaire was completed by the child's teacher and (if possible) by his or her speech-language therapist. Nine domains in this questionnaire were used: 1) Articulation, 2) Intelligibility, 3) Receptive Morphology, 4) Receptive Syntax, 5) Receptive Lexicon, 6) Expressive Morphology, 7) Expressive Syntax, 8) Expressive Lexicon, and 9) Pragmatics. The clinician was asked to indicate whether the child had 'No problems', 'Small problems', 'Moderate problems', or 'Severe problems' on the particular domain.

Procedure

Assessment was done by the staff specialists from the school or trained test assistants at the schools that the

Table 1 Description of tests per domain

Domain and tests	Description
Speech output	
Articulation	The child has to repeat 45 monosyllabic words. The answer is correct if the word is pronounced accurately.
Word Repetition Task	The child has to repeat 18 polysyllabic words (e.g., *koekoeksklok* meaning cuckoo clock). The answer is correct if the word is pronounced accurately.
Nonword Repetition Task	The child has to repeat 23 polysyllabic nonwords syllables (e.g., *booklienaa* and *sapada*). The answer is correct if the nonword is pronounced accurately.
Phonological Contrasts	The child has to imitate 15 pairs of words. The words within each pair differ from each other by one or two phonemes (e.g., *boeken–doeken* meaning *books–cloths*). First, the child hears one pair of words and sees two pictures, one after the other, representing both words. Then the child sees one picture (of cloths) and hears '*Dit zijn geen boeken, maar …* (*These are not books, but…*) and the child has to say the word *doeken* (*cloths*). After that, the child sees the picture of the other word and it hears *Dit zijn geen doeken, maar…* (*These are not cloths, but…*) and the child has to say *boeken* (*books*). The answer is correct if both words of one pair are pronounced accurately. Subsequently, the child has to name both pictures. The second answer is correct if both words of each pair are pronounced accurately.
Auditory perception	
Auditory Discrimination	The child hears 50 pairs of monosyllabic words and has to say whether the words are the same or different.
LAC-r 1a (Lindamood & Lindamood, 1979)	The child has to represent the number, sameness/difference, and order of two or three orally presented phonemes by placing colored blocks for 10 items. For example: /i/ - /e/.
LAC-r 1b (Lindamood & Lindamood, 1979)	The child has to represent the number, sameness/difference, and order of three orally presented phonemes by placing colored blocks for six items. For example: /b/ - /b/ - /z/.
LAC-r 2 (Lindamood & Lindamood, 1979)	The child has to represent the number, sameness/difference, and order of orally presented phonemes as a nonword by placing colored blocks for 12 items. For example: 'If this is "vops," show me "vaps."' The task is terminated when a total of five incorrect answers are given.
Morpho-syntactic abilities	
Function Words	The child sees three pictures and hears a sentence in which a function word constitutes the key for pointing to the correct picture.
Syntactic Patterns	The child sees three pictures and hears a sentence in which a syntactic pattern constitutes the key for pointing to the correct picture.
Sentence Reproduction	The child has to imitate twenty sentences. The total score is based on correct repetition of a specific function word and a specific syntactic pattern for each sentence.
Morphology	The child sees a picture and is provoked by an incomplete sentence to form the plural of 12 nouns ('This is one key, these are two …') and the past tense of 12 verbs ('Here you see Mary throwing the ball, yesterday she …').
Lexical abilities	
Receptive Vocabulary	The child has to choose one of four pictures as corresponding to an orally presented word. The maximum number of words is 96; the task is terminated after five consecutive incorrect answers.
Productive Vocabulary	The child has to name a picture. The maximum number of pictures is 60 but the test is ended after five consecutive incorrect answers. An answer is correct if the target word is named by the child. Articulation errors are not taken into account.
Definition	The child has to explain or describe the meaning of a given word. The maximum number of words is 45; the task is terminated after five consecutive incorrect answers.
Information processing	
Story Comprehension	The child has to listen to six short stories and after each story it has to answer four questions about the story.
Story Telling	The child is asked to tell the story that is represented by eight pictures. The task contains two stories, and each story is evaluated for 16 aspects of cohesion and coherence.
Number Recall (Kaufman & Kaufman, 1983)	The child has to repeat an orally presented sequence of numbers (e.g., *three, six, eight*).
Word Order (Kaufman & Kaufman, 1983)	The child has to point out an orally presented sequence of words (*house, bird, star*) in the correct order from a row of pictures representing the words.

Table 1 Continued

Domain and tests	Description
Rapid naming task	The child has to name 50 pictures of five different daily objects as fast as possible. The mean time per picture indicates rapid naming proficiency.
Pragmatics	
Children's Communication Checklist (CCC) (Bishop, 1998)	This checklist contains a series of statements describing aspects of the child's behavior. The teacher is asked to judge whether the statement 'Does not apply', 'Applies somewhat', 'Definitely applies', or is 'Unable to judge'. The *pragmatic composite score* comprises 38 statements distributed over 5 subscales: 'Inappropriate initiation', 'Coherence', 'Stereotyped conversation', 'Use of conversational context', and 'Conversational rapport'.

children attended. Children were tested for a total of three to five hours across a period of one to two months.

First, the initial test scores were submitted to a factor analysis in which scree plot and eigenvalue analyses indicated that four factors could be extracted for each age group. The eigenvalues of these factors were all >1.1. Therefore, the number of factors was set to four for the subsequent varimax rotation, producing orthogonal (i.e., uncorrelated) factors. Cases with missing values were excluded listwise. The standardized factor scores ($M = 0$, $SD = 1$) derived from the varimax analysis were next assigned to each child for each factor.

Second, the clinical judgments obtained from the teachers and speech-language therapists were then related to the empirically derived factors by means of Spearman's correlation coefficient (rho). High judgment scores indicated fewer problems on a specific domain and high factor scores indicated linguistic abilities that were better than those of the other children with SLI in the same age sample. Therefore, positive correlations between factor scores and judgment scores on the relevant domains were expected.

Finally, using the standardized factor scores, a cluster analysis was performed to find homogeneous subgroups of children that significantly differ from each other on the factors. The cluster analysis was performed in two steps. First, the optimal number of groups was determined by means of a hierarchical cluster analysis according to Ward (1963). This procedure starts with every child as a separate cluster. Stepwise, the two clusters with the smallest distance over all factors are detected and combined into one cluster, until all children are in the same cluster. The distance between two agglomerated clusters is called the 'fusion coefficient' and all fusion coefficients can be graphed into a hierarchical tree (a dendrogram). This graphical procedure is analogous to the 'scree plot test' of factor analysis that is used to determine the appropriate number of factors to derive (Aldenderfer & Blashfield, 1984). Ward's cluster analysis showed that a four-cluster solution was the most appropriate for each sample. However, all hierarchical procedures have the drawback that the final classification is not necessarily optimal. Therefore, the second step was to apply a K-means cluster analysis over the same factor scores with the number of clusters set to four. This procedure searched iteratively for four clusters for which the factors score profile of each child more closely resembles the mean profile of the members of the child's own cluster than the mean profiles of the members of the other clusters.

Results

Descriptive statistics

The results in Table 2 show both of the SLI samples to be significantly delayed on all of the language measures when compared to an age-related norm group of children with normal language development. For most language tests it was possible to calculate a *Z*-score on the basis of the mean and standard deviation of a norm group. The norm group for the 6-year-old sample with SLI consisted of 6-year-old children with normal language development at the end of kindergarten. The norm group for the 8-year-old sample with SLI consisted of 8-year-old children with normal language development at the end of second grade. Table 2 shows that the *Z*-scores were all negative and mostly smaller than −1, indicating a delay that is greater than one standard deviation. Qualitative comparison was possible for the remaining tests. On the Children's Communication Checklist (CCC), 27% of the 6-year-old sample and 21% of the 8-year-old sample had a score that was under the cut-off score of 132. This means that these children are identified by their teachers as having possible or definite pragmatic language impairment (Bishop, 1998). On the Nonword Repetition task, 6- and 8-year-old children with normal language development are expected to achieve the maximum score of 23. However, the 6-year-old children with SLI articulate on average 10 words correctly ($M = 9.95$, $SD = 4.96$), which resulted in a performance percentage of 43% (10 out of 23). The 8-year-old children with SLI had a performance percentage of 65% (15 out of 23) with $M = 14.98$ and $SD = 4.50$. On the Phonological Contrasts task, norm-group children of corresponding age are expected to achieve the maximum score of 30. The mean score of the 6-year-old children with SLI was 21.0 ($SD = 7.6$) and the mean score of the 8-year-old children was 26.2 ($SD = 5.1$). The performance percentages were 70% (21 out of 30) and 87% (26 out of 30) for the

Table 2 Differences between 6-and 8-year-old SLI groups and respective norm groups

		SLI		Norm		
Test	*N*	*Mean*	*SD*	*Mean*	*SD*	*Z*
Six-year-old sample						
Articulation	148	31.96	10.62	43.84	2.00	–[a]
Auditory Discrimination	148	39.16	9.42	46.10	5.05	−1.37
Definition	147	8.50	5.72	18.84	6.25	−1.65
Function Words	148	31.68	5.45	35.70	3.90	−1.03
LAC-r 1a	147	4.27	4.51	9.39	1.13	−4.53
LAC-r 1b	147	1.78	2.26	4.50	1.50	−1.81
LAC-r 2	147	1.73	2.95	5.52	3.73	−1.02
Morphology	148	10.05	4.61	15.70	4.40	−1.28
Number Recall (K-abc)	148	5.71	2.07	10.00	3.00	−1.43
Receptive Vocabulary	148	53.66	15.16	66.17	13.09	−.96
Sentence Reproduction	148	11.89	8.16	29.40	8.23	−2.13
Story Comprehension	147	14.50	4.95	17.91	4.38	−.78
Story Telling	148	13.29	6.68	18.23	6.46	−.76
Syntactic Patterns	148	29.41	5.67	34.20	4.50	−1.06
Word Order (K-abc)	148	6.16	2.12	10.00	3.00	−1.28
				Qualitative Comparison		
CCC	141	136.45	10.78	27% below the cut-off score 132		
Nonword Repetition	148	9.95	4.96	Mean performance percentage = 43% (10 out of 23)		
Phonological Contrasts	145	21.01	7.56	Mean performance percentage = 70% (21 out of 30)		
Productive Vocabulary	148	26.76	9.57	lowest 10% of norm scores		
Rapid Naming	147	1.79	.65	Between 30th and 40th percentile of first grade norm group		
Word Repetition	148	5.06	2.65	Mean performance percentage = 50% (5 out of 10)		
		SLI		Norm		
	N	*Mean*	*SD*	*Mean*	*SD*	*Z*
Eight-year-old sample						
Auditory Discrimination	134	46.15	4.57	49.06	1.86	−1.56
Articulation	134	40.75	5.05	44.85	.50	–[a]
Definition	134	15.94	7.55	27.90	5.98	−2.00
Function Words	134	36.77	3.30	39.13	2.50	−.94
LAC-r 1a	132	8.64	2.83	9.80	.99	−1.17
LAC-r 1b	132	4.41	1.88	5.13	.93	−.77
LAC-r 2	132	7.53	3.56	9.00	2.53	−.58
Morphology	134	15.69	5.24	21.34	3.00	−1.88
Number Recall (K-abc)	134	6.06	2.38	10.00	3.00	−1.31
Receptive Vocabulary	134	71.05	12.66	83.65	8.07	−1.56
Sentence Reproduction	134	20.78	7.99	35.52	4.95	−2.98
Story Comprehension	134	17.93	3.61	20.53	3.32	−.78
Story Telling	132	19.90	6.22	24.15	5.85	−.73
Syntactic Patterns	134	35.40	4.08	39.97	1.80	−2.54
Word Order (K-abc)	134	6.31	2.91	10.00	3.00	−1.23
				Qualitative Comparison		
CCC	122	140.29	9.52	21% below the cut-off score 132		
Nonword Repetition	133	14.98	4.50	Mean performance percentage = 65% (15 out of 23)		
Phonological Contrasts	132	26.22	5.12	Mean performance percentage = 87% (26 out of 30)		
Productive Vocabulary	133	37.83	8.68	lowest 10% of norm scores		
Rapid Naming	134	1.33	.32	Between 60th and 70th percentile of first grade norm group		
Word Repetition	133	7.51	2.10	Mean performance percentage = 75% (7,5 out of 10)		

[a] Norm group distribution of the Articulation test was not normal (i.e., showed a ceiling effect) and therefore, the *Z*-scores could not be calculated.

6- and 8-year-old SLI children, respectively. On the Productive Vocabulary task, the performance of the two SLI groups was comparable to the lowest 10% scores for age-related norm groups of 6- and 8-year

old children (Verhoeven & Vermeer, 1986). On the rapid naming task, the 6- and 8-year-old SLI children performed in the range 30th to 40th and 60th to 70th percentiles with respect to a norm group of first graders with normal language development. For this test, norm group information from older children was not available for comparison. Finally, on Word Repetition, the maximum score was 10 words to be repeated correctly. The average performance scores of the 6- and 8-year-olds were 50% (M = 5, *SD* = 2.65) and 75% (*M* = 7.5, *SD* = 2.1) respectively. In sum, quantitative and qualitative norm group comparisons of each age sample with SLI show a delay on all language and language-related tests that are used in this study.

Factor analysis

For the 6-year-old SLI sample, four factors were found to explain 62.1% of the variance in their language and language-related test scores. The eigenvalues for the different factors were 8.3, 2.2, 1.4, and 1.2. For the 8-year-old SLI sample, four factors were also found to explain 59.1% of the variance in their test scores with eigenvalues of 7.0, 2.3, 2.0, and 1.2. The initial four factors were then submitted to varimax rotation with Kaiser normalization for both SLI samples. The factor matrices were then examined, and factors defined in terms of variables with a loading of .3 or larger. The factors identified in such a manner can be seen to reflect the underlying structure of the tests used in the present study and different types of the broader problem of specific language impairment.

For the 6-year-old sample, the results of the factor analysis are presented in Table 3. The first factor consisted of tests that assess knowledge of word meaning (e.g., Receptive Vocabulary, Productive Vocabulary, and Definition) and tests that assess children's understanding of the meaning of texts and sentences (e.g., Story Comprehension, Syntactic Patterns, and Function Words). Therefore, this factor was labeled *lexical-semantic abilities*. With regard to the second factor, the Kaufman's sequential information processing tasks (i.e., Number Recall and Word Order) were found to load high on this factor, but also tasks measuring the children's syntactical abilities (i.e., the Sentence Reproduction task, Function Words, and Syntactic Patterns). To perform well on these syntactical tasks, sequential memory is a crucial ability. Furthermore, phonological tests that appeal to memory also had loadings on this factor, although less high (i.e. Phonological Contrasts and LAC-r 2). For this reason, the second factor was labeled *verbal sequential memory*. Note that the Pragmatic Composite Score of the CCC and the Rapid Naming task also had high loadings on the second factor. The third factor was labeled *speech production* because it was clearly defined by such measures as Word Repetition, Nonword Repetition, Articulation, and Phonological Contrasts. The fourth and final factor in the 6-year-old sample was mainly defined by the revised Lindamood Auditory Conceptualization task, which involves the representation of the number, sameness, and order of orally presented phonemes using colored blocks. Therefore, this factor was labeled *auditory conceptualization*.

For the 8-year-old sample, the results of the factor analysis are presented in Table 4. The first factor comprised measures of word meaning (e.g., Productive Vocabulary, Receptive Vocabulary, and Definition) and meaning of texts and sentences (e.g., Story

Table 3 Varimax rotated four-factor solution for the 6-year-old group (factor loadings >.30 are presented)

	Factor 1	Factor 2	Factor 3	Factor 4
Story Comprehension	.84			
Receptive Vocabulary	.77			
Productive Vocabulary	.77			
Syntactic Patterns	.73	.36		
Morphology	.67			
Function Words	.67	.36		
Definition	.52			
Sentence Reproduction	.50	.45		
Auditory Discrimination	.39			
Story Telling	.38			
Number Recall		.57		
Word Order		.57		
Pragmatic Composite Score (CCC)		.46		
Rapid Naming task		−.41		
Word Repetition			.85	
Nonword Repetition			.71	
Articulation			.68	
Phonological Contrasts	.41	.45	.46	
LAC-r 1b	.38			.81
LAC-r 1a	.38			.77
LAC-r 2	.33	.30		.56

Table 4 Varimax rotated four-factor solution for the 8-year-old group (factor loadings >.30 are presented)

	Factor 1	Factor 2	Factor 3	Factor 4
Productive Vocabulary	.73			
Receptive Vocabulary	.73			
Story Comprehension	.70			
Syntactic Patterns	.68			
Definition	.68			
Function Words	.63	.45		
Morphology	.58		.35	
Pragmatic Composite Score (CCC)	.40			
LAC-r 1a		.87		
LAC-r 1b		.74		
LAC-r 2		.74	.33	
Auditory Discrimination		.44		.36
Number Recall			.63	
Sentence Reproduction	.53		.62	
Word Repetition			.56	.49
Word Order–Rapid Naming Task			.46	
Nonword Repetition			.49	.63
Articulation		.43		.55
Phonological contrasts				.44
Story Telling				.43

Comprehension, Syntactic Patterns, and Function Words). This factor is comparable to the first factor in the 6-year-old sample and is also labeled *lexical-semantic abilities*. Note that the Pragmatic Composite Score of the CCC had high loadings on this factor. The second factor comprised mainly the revised Lindamood Auditory Conceptualization task and, similar to the third factor in the 6-year-old sample, was labeled *auditory conceptualization*. High loadings on the third factor were found on tests like Number Recall, Sentence Reproduction, Word Repetition, Word Order, and Nonword Repetition. The common factor in these tests is that they all assess how well a child is able to store and reproduce sequentially presented information. Therefore, this factor was labeled *verbal sequential memory*. The fourth and final factor for the 8-year-old sample was labeled *speech production* because it comprises mainly tests that measure the articulation of the child (i.e., Nonword Repetition, Articulation, Word Repetition, and Phonological Contrasts).

Clinical judgments correlates

In order to examine the criterion validity of the factors, clinical information regarding the speech and language problems of the children were collected from their teachers and – when possible – their speech therapists via a questionnaire. As can be seen from Table 5, clinical judgments were collected in the domains of Articulation, Intelligibility, Morphology (receptive and expressive), Syntax (receptive and expressive), Lexicon (receptive and expressive), and Pragmatics. The relations between the clinical judgments in these domains and the four statistically derived factor scores were then calculated with Spearman's rho and only significant correlations have been included in Table 5.

For the 6-year-old sample, *lexical-semantic abilities* are moderately correlated with the judgments of the clinicians on the Receptive-Lexicon (.57) and Expressive-Lexicon (.52) domains. However, similar correlations are found between *lexical-semantic abilities* and the Receptive-Morphology (.57) and Receptive-Syntax (.58) domains and less strong relations are found with the Expressive-Syntax (.45), Expressive-Morphology (.32), and Pragmatics (.30) domains. *Auditory conceptualization* is weakly related to the Receptive-Syntax domain and there are no significant correlations between this factor and the other domains of clinical judgments. *Verbal sequential memory* is weakly correlated with all of the domains (rho's are between .26 and .34), except for the Articulation and Intelligibility domain. *Speech production* is correlated with the clinical judgments on the Articulation (.57) and Intelligibility (.55) domains, and to a minor extent with those on the Expressive-Morphology (.20) domain.

For the 8-year-old sample, the same pattern of correlations can be seen in Table 5. *Lexical-semantic abilities* were correlated with clinical judgments on the Receptive-Lexicon (.54) and Expressive-Lexicon (.46) domains, but also with the Morphology (.38 and .42), Syntax (.49 and .38), and Pragmatics (.56) domains. No significant correlations were found between *auditory conceptualization* and any of the domains for which a clinical judgment was asked. *Verbal sequential memory* was correlated with all domains (rho's between .23 and .45) except for Articulation and Intelligibility. Finally, *speech production* was correlated with clinical judgments on the Articulation (.37) and Intelligibility (.37) domains and to a minor extent with Expressive-Morphology (.22) and Expressive-Syntax (.20).

Table 5 Significant correlations (Spearman's rho) between clinical judgments in several domains and four factor scores

	Factors							
	Six-year-olds				Eight-year-olds			
Clinical judgments	LS	AC	VSM	SP	LS	AC	VSM	SP
Articulation				.57**				.37**
Intelligibility				.55**				.37**
Receptive Morphology	.57**		.34**		.38**		.26**	
Expressive Morphology	.32**		.33**	.20*	.42**		.40**	.22*
Receptive Syntax	.58**	.19*	.34**		.49**		.32**	
Expressive Syntax	.45**		.33**		.38**		.45**	.20*
Receptive Lexicon	.57**		.26**		.54**		.23**	
Expressive Lexicon	.52**		.30**		.46**		.29**	
Pragmatics	.30**		.27**		.56**		.26**	

*$p < .05$, **$p < .01$.
Note: LS = Lexical-semantic abilities, AC = Auditory conceptualization, VSM = Verbal sequential memory, and SP = Speech production.

Cluster analysis

For both the 6- and 8-year-old SLI samples, a dendrogram of the Ward's hierarchical cluster analysis showed that the data of each sample with SLI clustered into four groups. A K-means cluster analysis was then conducted, with a restriction to four clusters for each SLI age group separately. Using this procedure, clusters that significantly differ from each other on as many factors as possible were formed and each child was assigned to one of the four clusters. In Figures 1 and 2, boxplots of these four clusters are displayed for each age sample. The units on the vertical axis are standard deviations from the mean of the standardized factor scores ($M = 0$ and $SD = 1$) of the particular age sample. A high mean factor score indicates that the cluster of children has a relatively good performance on the specific factor compared to the other clusters of the same age group. One should nevertheless keep in mind that all specific language impaired children have severe problems when compared to children with normal language development, as already shown in Table 2.

Figure 1 presents a boxplot of the clusters revealed for the sample of 6-year-old children with SLI.

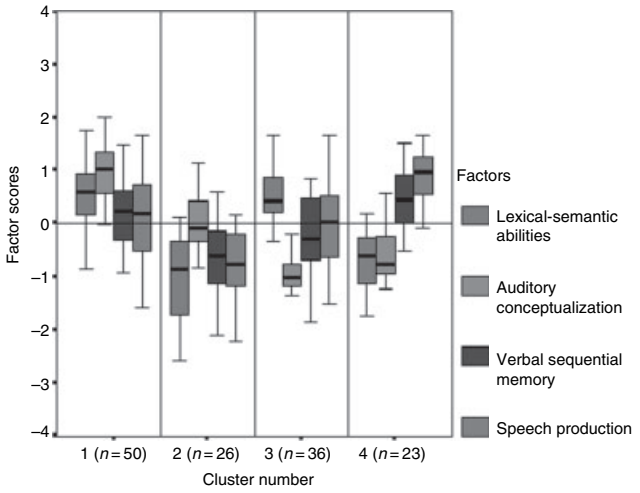

Figure 1 Boxplot for four clusters of the 6-year-old children with SLI

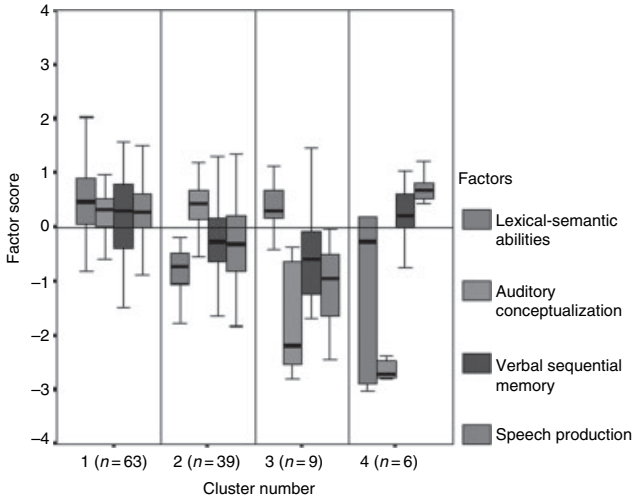

Figure 2 Boxplot for four clusters of the 8-year-old children with SLI

Thirteen children were not included in the cluster analysis due to listwise exclusion during the factor analysis. The remaining 135 children (100%) were clustered in four groups that significantly differed on all factors (p-values <.001 with one-way ANOVAs). The first cluster ($n = 50$ or 37%) contains children with relatively high standardized scores on all four factors when compared to the other 6-year-old clusters. Their highest factor scores are on *auditory conceptualization* and their lowest on *speech production*, but the mean factor score of *speech production* is above zero, indicating speech production abilities that are above mean when compared to all 6-year-olds with SLI. The second cluster ($n = 26$ or 19%) is the cluster with the most problems and contains children that have very low factor scores on *lexical-semantic abilities*, *verbal sequential memory*, *speech production*, and to a minor extent, on *auditory conceptualization*. The third cluster ($n = 36$ or 27%) showed relatively high scores on *lexical-semantic abilities*, low scores on *auditory conceptualization*, and mean scores on *verbal sequential memory* and *speech production* when compared to the other clusters within the same age sample. The fourth and smallest cluster ($n = 23$ or 17%) contains children that have low scores on *lexical-semantic abilities* and on *auditory conceptualization*, but high scores on *verbal sequential memory* and *speech production* when compared to the other clusters within the 6-year-old SLI age sample. In sum, the four clusters of 6-year-old children with SLI show distinct profiles with extremely low scores on a varying number of factors; cluster 1 has relatively high scores on all 4 factors, whereas cluster 3 has extremely low scores on 3 out of 4 factors.

Figure 2 presents the boxplot results for the 8-year-old children with SLI. Fifteen children were not included in the cluster analysis due to listwise exclusion during the factor analysis. The remaining 119 children (100%) were distributed rather unequally across the four clusters that were significantly different for every factor (p-values <.001 with one-way ANOVAs) except for *verbal sequential memory* ($F_{3,155} = 2.67$, $p = .051$). The first and largest cluster ($n = 65$ or 55%) contains children with relatively high scores on all factors when compared to the other clusters. The second cluster ($n = 39$ or 33%) contains children with relatively low standardized factor scores on *lexical-semantic abilities*, high scores on *auditory conceptualization*, and scores that are slightly under the mean on *verbal sequential memory* and *speech production*. The third cluster of children ($n = 9$ or 8%) showed particularly high scores on the factor *lexical-semantic abilities*, extremely low scores on *auditory conceptualization*, and low scores on *verbal sequential memory* and *speech production*. Strikingly, this cluster showed a large variation on 3 of the 4 factors, which is probably due to the small number of children. Finally, the fourth and smallest cluster ($n = 6$ or 5%) shows a large variation on *lexical-semantic abilities*, extremely low standardized factor scores on *auditory conceptualization*, and high scores on *verbal sequential memory* and *speech production*.

Conclusions and discussion

Several conclusions can be drawn from this study. First, the descriptive statistics show a significant delay on all language and language-related measures when the SLI groups of 6- and 8-year-old children are compared to age-related norm groups of children with normal language development. The measures used in the present study cover a broad range of language domains on which children with SLI are impaired, providing a strong theoretically validated basis of the test battery used in this study.

Second, the test scores appear to represent four orthogonal factors or the *lexical-semantic*, *auditory conceptualization*, *verbal sequential memory*, and *speech production* abilities of children and thus four latent aspects of the language problems experienced by children with SLI in the Netherlands. The stability of the four factors is confirmed by the fact that they appear to underlie the data for both the 6- and 8-year-old children, although part of the similarity between the outcomes of both age samples is due to the fact that the same tests were entered in the factor analysis.

A third conclusion that can be drawn is that the validity of the children's factor scores was supported by the clinical judgments of their teachers and speech therapists. A high correlation was found between *lexical-semantic abilities* and the specialist's judgments on Lexicon, Syntax and to a minor extent, Morphology. This is not surprising considering the fact that tasks measuring syntactic abilities also loaded on the factor *lexical-semantic abilities*. It only confirms the idea that these linguistic abilities are hard to discriminate in both test scores and clinical practice. The factor *auditory conceptualization* showed hardly any correlation with the judgments. This can be explained by the fact that this factor measures primarily metalinguistic skills that can scarcely be observed in daily life. Less high, but still significant relations were found between scores on the factor *verbal sequential memory* and the judgments in the Morphology, Syntax and Lexicon domains (both expressive and receptive). The factor *speech production* mainly showed correlations with the judgments in the Articulation and Intelligibility domains. In short, it can be stated that the clinical checklist strengthens the criterion validity of the factors.

Fourth, the cluster analyses showed that the SLI children of both age samples clearly fell into four clusters. Comparison of the two SLI age groups revealed several similarities (see Figures 1 and 2 for the 6- and 8-year-olds, respectively). Both age groups contain a cluster of children showing relatively high scores on all factors (i.e., cluster 1 in both age samples). This means that their language and language-related abilities, as visualized by the factor scores in the boxplots, are relative good when compared to the other children with SLI in the same age sample. However, compared to a norm group of children with normal language development, the children with SLI are severely delayed. In both age samples this first cluster is also the largest. An important finding is that within this cluster the problems on the four linguistic factors are relatively comparable in severity. In other words, these children show impairment on all language factors, but they are not extremely impaired on any of the factors. Whereas the 6-year-old children in cluster 1 show a small peak in *auditory conceptualization*, the 8-year-old children in cluster 1 have median scores that are practically the same (a factor score around .5). The second cluster in the 6-year-old age sample is also comparable to the second cluster in the 8-year-old sample. Here, scores on *lexical-semantic abilities* are relatively low, high on *auditory conceptualization*, and slightly below the mean of zero on *verbal sequential memory* and *speech production*. The profiles of the children in clusters 3 and 4 are comparable between the two age samples as well, but the number of children in clusters 3 and 4 is drastically smaller in the 8-year-old sample. This may indicate that the specific profiles of these clusters 3 and 4 are less frequently present in older children with SLI. Although this study is not longitudinal, the results seem to imply that, as children age, their profile can change in one of two directions. Specifically, they may 'move' to another SLI cluster, or it may be that these children no longer meet the SLI criteria at this age. The third and fourth clusters contain children with very low scores on *auditory conceptualization* and the fact that in the 8-year-old sample these clusters are very small may indicate maturation of phonology during the period between the ages of six and eight. However, it should be remembered that both age samples are different cohorts and that longitudinal conclusions cannot be drawn from these results.

Furthermore, an interesting finding is that the factor *lexical-semantic abilities* not only comprises tests that measure vocabulary, but also tests that measure syntactical abilities. Apparently, understanding the meaning of sentences requires understanding the meaning of words, and for learning new words that are presented in sentences understanding of grammatical rules is necessary. This may reflect the learning mechanism called 'bootstrapping' (Gleitman, 1990; Pinker, 1989). The bootstrapping theory hypothesizes that children can use cues such as prepositions, inflectional morphology, and the position of noun phrases to identify underlying syntactic-argument structure, and that this knowledge can, in turn, be used to determine likely semantic components. Several studies provided evidence for a primary grammatical deficit in children with SLI (i.e., Grammatical SLI) that leads to semantic deficits, because the child is unable to use syntactic bootstrapping to deduce word meanings (Bishop, Bright, James, Bishop, & Van der Lely, 2000; Rice, Cleave, & Oetting, 2000; Van der Lely, 1994). However, Bishop et al. (2000) also concluded that most children who made grammatical errors characteristic of Grammatical SLI had co-occurring deficits in other areas outside the syntactic system. Furthermore, it is suggested that a possible cause for this grammatical deficit is processing limitations (Joanisse & Seidenberg, 1998; Gathercole & Baddeley, 1990a; Leonard, 1998; O'Hara & Johnston, 1997). This is in accordance with our results because the first factor (with the most variance explained) comprised both syntactic and lexical-semantic ability tasks and the

factor *verbal sequential memory* (second factor for the 6-year-old and third factor for the 8-year-old data in Tables 3 and 4, respectively) comprises syntactical tests (i.e., Syntactic Patterns, Function Words, and Sentence Reproduction). It is likely that children with the profile of the second cluster (in both age groups) are comparable to the grammatical SLI group, but detailed grammatical error analyses are needed to draw firm conclusions about this.

Another interesting finding is that the factor scores on *verbal sequential memory* and on *speech production* have comparable medians and standard deviations in all clusters for both age samples. The factor scores are derived from a varimax rotation that produces orthogonal factor scores, which means that the factors are independent or, in other words, not correlated. However, the similar scores on *verbal sequential memory* and *speech production* per cluster may indicate that the two linguistic factors are interrelated in some sort of way. It is likely that the tests that comprise *speech production* also require verbal memory skills to perform well. In order to repeat a word properly, the child has to hold it in his or her short-term memory first, before reproducing the word. Besides this, nonword repetition tasks are also present in the factor *speech production*. According to some researchers, nonword repetition tasks appeal to phonological-working memory and therefore play a role in learning new words (Gathercole, 1995; Gathercole & Baddeley, 1990b). This would mean that low scores on *verbal sequential memory* and *speech production* go hand in hand with low scores on *lexical-semantic abilities*. This is only the case for the second cluster in both 6- and 8-year-old samples. The question of whether the problem lies in the limited capacity of retaining the phonological information or in inappropriately encoding of the information, as Bishop (1997) points out, cannot be answered in this study.

Several other issues remain to be investigated in future research. For example, language problems have been found to change over time (Bishop & Edmundson, 1987). The linguistic profiles of certain clusters of children in this study may also change over time and/or children may move from one cluster to another with time as was found by Conti-Ramsden and Botting (1999). Some evidence for the stability of the factors in the present study is provided by the fact that in two different SLI age groups, the same linguistic profiles emerged. However, in the 8-year-old sample, the third and fourth clusters were very small. This could indicate that after the age of 6 or 7, children that initially fall in the third or fourth cluster 'change' clusters or even no longer meet the SLI criteria and are therefore not taken into account in this study. Longitudinal data are needed to investigate the stability of the factors and clusters of children over time. The question of whether different linguistic profiles can be taken to reflect a different pathophysiology (i.e., underlying brain dysfunction) remains as yet unanswered. The possibility still remains that a single disorder may manifest itself in any of a number of ways.

Another issue concerns the results on the pragmatic composite score. Pragmatic ability can be defined as the ability to establish linkages between linguistic forms and the most appropriate and effective communicative function in relation to the context in which it occurs (Bishop & Baird, 2001; Craig, 1995; van Balkom & Verhoeven, 2004). In the 6-year-old sample, factor analyses show that the pragmatic composite score is related to the factor *verbal sequential memory*. In the 8-year-old sample it is to the *lexical-semantic abilities*. Although the factor loadings were rather low, the results may indicate that in some children with SLI, the lexical-semantic knowledge of concepts and words is not adequately stored, which may be caused by processing and/or short-term memory limitations. As a result, these SLI children may have difficulties in the formation and specification of mental concepts. Perceptual, processing, and storage limitations may lead to difficulties in recognizing essential properties of new words and concepts, and the capacities to adequately analyze and link critical properties to already existing experiential and lexical-semantic knowledge may be limited. Furthermore, the appropriate form–function mappings during discourse may be ineffective, again due to the processing limitations (Craig, 1995). However, to draw any firm conclusion about these supposed relations, further research is needed with a more detailed look at the pragmatic composite score in a one-on-one relation with other language problems.

An important practical implication of the present study concerns the possibility that a child with SLI may have more than one linguistic deficit and that some linguistic deficits may be more severe than others. The results provide evidence for the view that a complex structure of compensating and restricting factors in language acquisition is present within each child with SLI. Compensatory strategies of children in different SLI clusters, as distinguished in this study, can vary and perhaps change over time within the same child. In future intervention studies, a dynamic perspective may be helpful in explaining the progress or stagnation in language acquisition in children with SLI. A dynamical systems theory considers the view that language acquisition is the result of a continuous, dynamic interaction between the biological properties of the child and the environment (Thelen & Smith, 1994). An interesting example is given by van Geert (2004): When intervention is focused on enhancing vocabulary, syntactic abilities are most likely to benefit because if children have a good representation of the meaning of various words, it is easier for them to acquire the grammatical morphology associated with these words. This is the 'bootstrapping' effect mentioned earlier (Gleitman, 1990;

Pinker, 1989). However, when a severe deficit in phonological processing is also present in the child, the functions of processing lexical and syntactic information are no longer mutually supporting, but mutually competing functions because they compete for the scarce resource on attention and working memory (van Geert, 2004). Thus, as Evans (2001) states, for intervention it is not enough to know in which aspects of language (e.g., vocabulary, morphology, syntax, and pragmatics) the child with SLI does or does not have a deficit. It is even more important for future research to find out more about the mechanisms that are involved in the change in language abilities over time.

Acknowledgements

This research was partially supported by *Viataal*, St. Michelsgestel, the Institute *St. Marie*, Center for Assessment and Treatment of Children and Adolescents from the age of 2 to 25 years with Auditory and/or Communicative Disabilities, Eindhoven, The Netherlands, the Mgr. J.C. van Overbeek Foundation, Den Bosch, and *Simea*, The Netherlands. Special appreciation is expressed to the children who participated, their parents, teachers, and clinicians of the participating schools.

Correspondence to

M.W.C. van Weerdenburg, Department of Special Education, Radboud University Nijmegen, P.O. Box 9104, 6500 HE Nijmegen, The Netherlands; Tel: 0031 (0)24-3612969; Email: M.vanWeerdenburg@pwo.ru.nl

References

Aldenderfer, M.S., & Blashfield, R.K. (1984). *Cluster analysis*. London: Sage.

Allen, D.A., & Rapin, I. (1992). Autistic children are also dysphasic. In H. Naruse & E.M. Ornitz (Eds.), *Neurobiology of infantile autism* (pp. 157–168). Amsterdam: Excerpta Medica.

Aram, D.M., Morris, R., & Hall, N.E. (1993). Clinical and research congruence in identifying children with specific language impairment. *Journal of Speech and Hearing Research*, *36*, 580–591.

Beitchman, J.H., Hood, J., Rochon, J., Peterson, M., Mantini, T., & Majumdar, S. (1989). Empirical classification of speech/language impairment in children. (Part) I: Identification of speech/language categories. *Journal American Academy of Child Adolescent Psychiatry*, *28*, 112–117.

Bishop, D.V.M. (1992). The underlying nature of specific language impairment. *Journal of Child Psychology and Psychiatry*, *33*, 3–66.

Bishop, D.V.M. (1997). *Uncommon understanding. Development and disorders of language comprehension in children*. Hove: Psychology Press.

Bishop, D.V.M. (1998). Development of the children's communication checklist (CCC): A method for assessing qualitative aspects of communicative impairment in children. *Journal of Child Psychology and Psychiatry*, *39*, 879–892.

Bishop, D.V.M. (2004). Diagnostic dilemmas in specific language impairment. In L. Verhoeven & J. van Balkom (Eds.), *Classification of developmental language disorders* (pp. 309–326). Mahwah, NJ: Erlbaum.

Bishop, D.V.M., & Baird, G. (2001). Parent and teacher report of pragmatic aspects of communication: Use of the Children's Communication Checklist in a clinical setting. *Developmental Medicine and Child Neurology*, *43*, 809–818.

Bishop, D.V.M., Bright, P., James, C., Bishop, S.J., & Van der Lely, H.K.J. (2000). Grammatical SLI: A distinct subtype of developmental language impairment? *Applied Psycholinguistics*, *21*, 159–181.

Bishop, D.V.M., & Edmundson, A. (1987). Language-impaired four-year-olds: Distinguishing transient from persistent impairment. *Journal of Speech and Hearing Disorders*, *52*, 156–173.

Bishop, D.V.M., & Leonard, L.B. (Eds.). (2000). *Speech and language impairments in children: Causes, characteristics, intervention and outcome*. Hove: Psychology Press.

Bishop, D.V.M., & Norbury, C.F. (2002). Exploring the borderlands of autistic disorder and specific language impairment: A study using standardised diagnostic instruments. *Journal of Child Psychology and Psychiatry*, *43*, 917–929.

Botting, N., Conti-Ramsden, G., & Crutchley, A. (1997). Concordance between teacher/therapist opinion and formal language assessment scores: Differences across separate areas of language impairment. *European Journal of Disorder of Communication*, *32*, 317–327.

Craig, H.K. (1995). Pragmatic impairments. In P. Fletcher & B. MacWhinney (Eds.), *The handbook of child language* (pp. 623–640). Oxford: Blackwell.

Conti-Ramsden, G., & Botting, N. (1999). Classification of children with SLI: Longitudinal considerations. *Journal of Speech and Hearing Disorders*, *42*, 1205–1219.

Conti-Ramsden, G., Crutchley, A., & Botting, N. (1997). The extent to which psychometric tests differentiate subgroups of children with SLI. *Journal of Speech, Language, and Hearing Research*, *40*, 765–777.

Evans, J.L. (2001). An emergent account of language impairment in children with SLI: Implications for assessment and intervention. *Journal of Communication Disorders*, *34*, 39–54.

Gathercole, S.E. (1995). Is nonword repetition a test of phonological memory or long-term knowledge? It all depends on the nonwords. *Memory and Cognition*, *23*, 83–94.

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

Gathercole, S.E., & Baddeley, A.D. (1990b). The role of phonological memory in vocabulary acquisition: A study of young children learning new names. *British Journal of Psychology*, *81*, 439–454.

Gleitman, L. (1990). The structural sources of verb meaning. *Language Acquisition*, *1*, 3–55.

Haynes, C., & Naidoo, S. (1991). *Children with specific speech and language impairment (vol. 119)*. Oxford: Mac Keith Press.

Joanisse, M.F., & Seidenberg, M.S. (1998). Specific language impairment: A deficit in grammar or processing? *Trends in Cognitive Sciences*, *2*, 240–247.

Kaufman, A.S., & Kaufman, N.L. (1983). *Kaufman Assessment Battery for Children: Interpretative manual*. Circle Pine, MN: American Guidance Service.

Leonard, L.B. (1998). *Children with specific language impairment*. Cambridge: Mac Keith Press.

Levelt, W.J.M. (1989). *Speaking: From intention to articulation*. Cambridge: Bradford.

Lindamood, C.H., & Lindamood, P.C. (1979). *Lindamood Auditory Conceptualization (LAC) Test – revised*. Austin, TX: Pro-Ed.

Maassen, B., & van der Meulen, S. (2000). Differentiaal Diagnostisch Articulatie Onderzoek (DDAO) [Differential diagnostic articulation test]. *Logopedie en Foniatrie*, *72*, 159–161.

Miller, J.F. (1987). A grammatical characterization of language disorder. In J.A.M. Martin, P. Fletcher, P. Grunwell, & D. Hall (Eds.), *Proceedings of the First International Symposium on Specific Speech and Language Disorders in Children* (pp. 100–114). London: AFASIC.

O'Hara, M., & Johnston, J. (1997). Syntactic bootstrapping in children with specific language impairment. *European Journal of Disorders of Communication*, *32*, 147–163.

Pinker, S. (1989). *Learnability and cognition. The acquisition of argument structure*. Cambridge: MIT Press.

Rapin, I. (1996). Practitioner review: Developmental language disorders: A clinical update. *Journal of Child Psychology and Psychiatry*, *37*, 643–655.

Rapin, I., & Allen, D. (1983). Developmental language disorders: Nosologic considerations. In U. Kirk (Ed.), *Neuropsychology of language, reading and spelling* (pp. 155–184). New York: Academic Press.

Rapin, I., & Allen, D. (1987). *Developmental dysphasia and autism in pre-school children*. Paper presented at the Proceedings of the First International Symposium on Specific Speech and Language Disorders in Children (AFASIC), London.

Rice, M.L., Cleave, P.L., & Oetting, J.B. (2000). The use of syntactic cues in lexical acquisition by children with SLI. *Journal of Speech, Language and Hearing Research*, *43*, 582–894.

Smithson, M. (2000). *Statistics with confidence*. London: Sage.

Stark, R.E., & Tallal, P. (1981). Selection of children with specific language deficits. *Journal of Speech and Hearing Disorders*, *46*, 114–180.

Thelen, E., & Smith, L. (1994). *A dynamic systems approach to the development of cognition and action*. Cambridge, MA: MIT Press.

van Balkom, H., & Verhoeven, L. (2004). Pragmatic disability in children with specific language impairments. In L. Verhoeven & H. van Balkom (Eds.), *The classification of developmental language disorders: Theoretical and clinical implications*. New York: Erlbaum.

van Bon, W.H.J. (1986). *Coloured Progressive Matrices: Manual of Dutch norms*. London: Lewis.

Van der Lely, H.K.J. (1994). Canonical linking rules: Forward versus reverse linking in normally developing and specifically language-impaired children. *Cognition*, *51*, 29–72.

van Geert, P. (2004). A dynamic systems approach to diagnostic measurement of SLI. In L. Verhoeven & H. Van Balkom (Eds.), *Classification of developmental disorders: Theoretical issues and clinical implications*. London: Erlbaum.

Verhagen, W., & Aarnoutse, C. (2000). *Rapid Naming Task*. Nijmegen, The Netherlands: Nijmegen University.

Verhoeven, L., & van Balkom, H. (Eds.) (2004). *Classification of developmental language disorders. Theoretical issues and clinical implications*. London: Erlbaum.

Verhoeven, L., & Vermeer, A. (1986). *Taaltoets Allochtone Kinderen* [Language Proficiency Test for Children with Dutch as a second language]. Arnhem: Cito.

Verhoeven, L., & Vermeer, A. (2001). *Taaltoets Alle Kinderen* [Language Proficiency Test for All Children]. Arnhem: Cito.

Ward, J.H. (1963). Hierarchical grouping to optimize an objective function. *Journal of the American Statistical Association*, *58*, 236–244.

Wilson, B., & Risucci, D. (1986). A model for clinical quantitative classification. Generation 1: Application to language-disordered preschool children. *Brain and Language*, *27*, 281–309.

Manuscript accepted 6 January 2005