Variation of Language, Cognition and Behavior in Children with Specific Language Impairment

John van Daal

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Variation of Language, Cognition and Behavior in Children with Specific Language Impairment

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Voorwoord

In 1998 werd een start gemaakt met de zogeheten VeBoss-KUN studie. Deze studie werd opgezet om psychometrische evidentie te leveren voor de classificatie van taalvaardigheden van kinderen met ernstige spraak-taal moeilijkheden (ESM). Dit onderzoek naar classificatie van taalvaardigheden van kinderen met ESM richtte zich dus ten eerste op de vraag of verschillende aspecten van taalontwikkeling bij kinderen met ESM onderscheiden konden worden. Dit onderzoek vond mede plaats in het kader van de ontwikkeling van indicatiecriteria voor plaatsing op het speciaal onderwijs, type cluster 2, welke nodig waren om de slagboom voor hulp vanuit het speciaal onderwijs aan kinderen met ernstige spraaktaal moeilijkheden open te laten gaan. Met dit doel voor ogen werden 110 kinderen op een leeftijd van gemiddeld 4.5 jaar, welke op basis van klinische expertise reeds dit type onderwijs bezochten, enkele malen onderzocht. Naast taalonderzoek werd ook onderzoek verricht naar aspecten van de cognitieve ontwikkeling en het gedragsbeeld.

De uit dit onderzoek geopperde classificatie van ESM is inmiddels door de landelijke commissie toezicht indicatiestelling (LCTI) overgenomen. De resultaten van het onderzoek sluiten tevens aan bij internationale inzichten met betrekking tot de classificatie van taalontwikkeling en daarmee samenhangende aspecten, zoals het auditief werkgeheugen en bepaalde gedragsproblemen. Ik wil op deze plaats dan ook de hoop uitspreken dat dit onderzoek een stimulans vormt voor verder wetenschappelijk onderzoek bij kinderen met Ernstige Spraak-taal Moeilijkheden. Er is nog veel te ontdekken op het gebied van diagnostiek, oorzaken, co-morbiditeit en behandelingsmethodieken ten aanzien van kinderen, maar ook adolescenten en volwassenen, met ernstige spraak-taalmoeilijkheden!

Aanleiding voor dit onderzoek vormde een samenwerking tussen Sint Marie te Eindhoven, alwaar ik tot medio 2007 werkzaam ben geweest, en de vakgroep orthopedagogiek van de Radboud Universiteit te Nijmegen. De respectievelijke directies van Sint Marie, achtereenvolgens Ted Raedts-Thomassen, Geert Derks en Elly Laanen, hebben mij steeds gesteund en gestimuleerd in mijn onderzoek. Vooral de bezieling en het enthousiasme van Ted Raedts waren onmisbaar om dit onderzoek, naast mijn klinisch werk, te kunnen opzetten, uitvoeren en afronden. Ted, ik ben je daarvoor zeer dankbaar. Daarnaast heb ik door de jaren heen met vele inhoudelijke collega’s gestoeid, gepiekerd en genoten van de onderzoeksperikelen. Wetende dat ik zeker mensen zal vergeten,waarvoor ik me bij deze oprecht wil verontschuldigen, wil ik Juliane Cuperus, Harry Simkens en Kino Jansonius bedanken voor hun inzichten, commentaren en persoonlijk klankbord. Ik denk vooral terug aan de vele gedachtewisselingen die ik met Juliane Cuperus heb gehad. Ook voor jou Juliane een speciaal woord van dank!

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John van Daal

Chapter 1

Introduction

In this dissertation, a Dutch study of the classification of Specific Language Impairment (SLI) among young children in the age range of four to six years is reported on. As part of the research endeavor, not only the language skills of the children were studied but also those areas of development that are, according to the literature, strongly allied with language problems, namely, cognitive and behavior problems (e.g., Johnston, 1994; Brownlie, Beitchman, Escobar, Young, Atkinson, Johnson, Wilson, & Douglas, 2004).

In the international literature, SLI is defined as a language development problem without accompanying intellectual limitations, hearing problems, motoric problems, social-emotional problems or neurological problems (Stark & Tallal, 1981). This definition of SLI is primarily intended to guide the selection of children with language disorders for scientific research purposes. At the same time, the definition is often used in clinical practice to identify those children entitled to special education (or not). A marked discrepancy between nonverbal and verbal IQ is often adopted, in particular, as a measure of the severity of the language disorder. The results of different studies, however, show many children who appear to have no developmental problems according to an IQ test to nevertheless display unexpectedly high discrepancies in their verbal versus nonverbal IQs while other children with clearly evident language problems according to an IQ test display very few or no such discrepancies whatsoever (Aram, Morris, & Hall, 1992; Cole, Dale, & Mills, 1992; Leonard, 1998; Plante, 1998). The prevalence of SLI is also difficult to determine. Due in part to the absence of clear inclusion criteria for SLI as a diagnostic category but also to differences in the degree of statistical deviation of the language development employed for diagnostic purposes, the prevalence figures of children having SLI can range from 2.5% to 12.6% (Tomblin, Records, Buckwalter, Zhang, Smith, & O'Brien, 1997). When the lowest incidence is considered, it can be seen that Tomblin draws upon a study by Randall, Reynell, and Curwen (1974) in which a delay on the Reynell language test of two standard deviations is taken as the criterion of having SLI.

Diagnostic criteria and prevalence figures have been largely supplied by epidemiological studies in the past. To establish indication criteria for children in need of special treatment and/or education, however, a research group with clearly clinical language problems should be considered. That is, the language development of this specific group of children should be studied, and a critical question in doing this is the extent to which SLI can be viewed as unifactorial or multifactorial. The search for the valid classification of young children with clinically evident SLI thus constitutes the core focus in this dissertation.

Classification of SLI

The classification of language problems in clinical populations has previously been the topic of considerable discussion and research in particularly the UK and the USA. In Table 1, an overview of the most important studies undertaken in the field during the past decade is presented. The methods used and most important findings are also very briefly summarized for each of the studies. As can be seen, the overview provides evidence for a multifactorial conceptualization of language development and the language problems of children with SLI as well but also shows the underlying picture to be far from clear. Both the number and nature of the different aspects of SLI identified in the studies appear to vary. The divergent findings can perhaps be explained in terms of the different research populations and different research methods (e.g., tests, questionnaires, and observations) used to determine the nature of the language problems. However, recent linguistic theory also provides support for the view that language development and the language problems of children may be multifactorial (Bishop, 1997; Levelt, 1989). The domains of language distinguished in numerous studies are phonology, syntax, lexicon, semantics, and pragmatics (Bishop, 1992 & 2004; Hoof & Shatz, 2007; Leonard, 1998).

On the basis of the preceding, an extensive test battery was put together in the present research to study a population of children with SLI. In such a manner, a large database was established with numerous language variables, which could then be factor analyzed.

Language development in children with SLI

Numerous studies have shown the language development of children with SLI to not be stable. While some young children with SLI clearly catch up to their peers by the age of six years, other children with SLI are still found to have language problems at this age and the language problems usually prove persistent then (Bishop & Edmundson, 1987). In an extensive study of seven-year-old children with SLI, 242 children were classified into six SLI subgroups. When re-tested one year later at the age of eight years, 45% of the children were classified differently (i.e., assigned to a different subgroup). Language develops gradually and happens on the basis of the interaction between different types of processes that can emerge over time, intensify, and possibly disappear.

Dynamic system theory clearly fits in here as this theory relies upon neural network models, which are not static and can therefore change during the course of development, to approach cognitive development and, in our case, language development (Elman, Bates, Johnson, Karmiloff-Smith, Parisi, & Plunkett, 1996).

Table 1: Review of classification studies.

Authors	**Aram & Nation, 1975**	**Wolfus, Moscovitch & Kinsbourne, 1980**	**Rapin & Allen, 1983**	**Wilson & Risucci, 1986**	**Haynes & Naidoo, 1991**	**Fletcher, 1991 & 1992**	**Conti-Ramsden, Crutchley & Botting, 1997**	**Rapin & Allen 1996**
Method	47 preschool language-disordered children (3;2-6;11 years), diagnosed by speech & language pathologists were studied using an extensive battery of language tasks. Q-technique factor analysis used to identify subgroups.	19 children between 4.3 and 7.5 years, diagnosed by speech & language pathologists were administered a battery of syntactic, syllable-sequencing and phonological tasks. Discriminant function analysis used to identify subgroups.	Subgroups were determined by clinicians on the basis of systematic observation of conversational skills in an interactive play setting.	93 children (36-61 months), diagnosed by a neurologist and speech/language pathologist were administered a language battery.	156 children with severe speech & language problems in the age range of 5 to 13 years were studied via analysis of school files.	15 language impaired children(6;2-9;11 years) were studied on the basis of spontaneous speech samples of conversation with an unknown adult.	242 children (6;6-8 years) with language impairment using a assessment battery covering a broad range of language abilities. Cluster-analysis used to identity subgroups.	Review of the literature from the clinical perspective of a child neurologist
Subgroups distinguished	Repetition strength pattern Nonspecific formulation-repetition disorder Generalized slow pattern Syntactic and speech programming disorder	Expressive group with syntax production problems and syllable production problems Expressive-receptive group with difficulties on comprehension and production of syntax	Semantic-pragmatic disorder Phonologic-syntactic disorder Verbal auditory agnosia Phonologic production and speech planning disorder Lexical-syntactic deficit	Auditory-semantic comprehension disorder Auditory and visual semantic comprehension disorder Auditory-semantic comprehension and auditory/visual short-term memory disorder Expressive and/or receptive disorder Global disorder Auditory memory and retrieval disorder Expressive disorder	Speech Speech Plus (also language problems) Classic (expressive language problems) Semantic (comprehension problems) Residual (no severe impairment in any language area) Moderate No language development Young severe unclassified (no testing possible) Severe	Discourse and semantic problems Rate and fluency problems Phonological/ grammatical problems Linguistic structure-building problems	Receptive-expressive syntax and morphology Expressive phonology Articulation, phonology, expressive problems and other problems Pure articulation problems, phonology and expressive problems Poor on all language measures Semantic-pragmatic problems	Semantic-pragmatic disorder Lexical-deficit disorder Phonologic-syntactic disorder Verbal auditory agnosia Speech programming deficit disorder Verbal dyspraxia

From such a perspective, research is conducted on the interrelations between the different components of language during the development of language (van Geert, 2004) and the development of the various components themselves (Joanisse, 2004; MacWhinney, 1998).

In the research reported on in this dissertation, the aforementioned findings were incorporated into the formulation of a number of specific research questions. To start with, the children in the present research were studied from a longitudinal perspective and thus on three occasions, namely at the ages of four, five, and six years. In such a manner, the stability of the identified language factors could be analyzed over time. With the adoption of a longitudinal approach to the collection of the data to be analyzed, the relations between various language skills could also be analyzed over time. And in such a manner, whether or not one can speak of so-called bootstrapping during the course of the children's language development could be considered. Bootstrapping is understood to be the facilitation of the development of various language components by the skill acquired for a different but related language component. One can thus, for example, speak of phonological bootstrapping when improved phonological skills are found to promote the development of the lexicon (Adams & Gathercole, 1995; Christophe, Guasti, Nespor, Dupoux, & van Ooyen, 1997). Similarly, one can speak of syntactic bootstrapping when syntactic development is found to promote and lexical development (Bates & Goodman, 1999).

The role of cognition in language impairments

As already mentioned, because of the original inclusion criteria for *research* purposes, it was long assumed that children with SLI should not have cognitive problems. Children with SLI were assumed to have average nonverbal intelligence. However, the research mentioned in the foregoing showed this to *not* be the case for many children classified as having SLI. That is, children with SLI were generally assumed to have an average nonverbal intelligence. Groups of children who showed diminished nonverbal intelligence in addition to SLI were nevertheless found in actual *clinical* practice (see, among others, Dockrell & George, 1997). These more recent findings thus prompted initiatives to establish a new domain of scientific research on the relations between SLI and comorbid cognitive problems (e.g., Bishop, 1997; Gillam, Cowan, & Marler, 1998; Johnston, 1994; Martin & Saffran, 1997). In one such line of research, the central hypothesis is that the information processing of children with SLI proceeds slower than the information processing of other children (Hayiou-Thomas, Bishop, & Plunkett, 2004; Kail, 1994). In a different line of research, children's auditory information processing is studied under the presupposition that delays in this domain may relate to delays in the development of speech and language (e.g., Tallal, 2000). Still other researchers are studying the role of working memory in SLI (e.g., Mainela-Arnold & Evans, 2005) and, in

doing this, a distinction is commonly made between working memory in general and auditory working memory in particular. In still other studies of the role of working memory, the model of Baddeley in which working memory is assumed to consist of phonological working memory, visual working memory, and a central executive component is called upon (Baddeley, 2003). And in many of these studies, a relation between weak phonological working memory and SLI has been demonstrated although many questions still exist with respect to the exact nature of the problems. Certain auditory working memory problems appear to be hereditary while others appear to be more environmental, for instance (Bishop, Adams, & Norbury, 2006). Empirical evidence for visual working memory problems and executive working memory problems on the part of children with SLI has also been found, but the number of studies is still quite limited (e.g., Hoffman & Gillam, 2004).

Virtually lacking within this field of research to date is the study of the possible relations between neurocognitive information-processing problems and specific forms of specific language problems. The extent to which relations between information-processing problems and underlying language factors can thus be identified for a population of children with SLI was therefore examined in the present research.

Behavior problems in children with SLI

Another exclusion criterion for the identification of children with SLI for *research* purposes is the absence of behavior problems. Again however, in *clinical* practice behavior problems appear to frequently occur among children with SLI. The nature of the behavior problems varies from outwardly oriented, externalizing problems such as aggression and norm-violating behavior to inwardly oriented, internalizing problems such as anxiety, depression, and social problems (e.g., Brownlie et al., 2004). Many children with SLI have problems with social relations, are teased, and/or have a low self-image (e.g., Conti-Ramsden et al., 2004). One can also speak of ADHD due to problems with attention/concentration and impulse regulation for some children in addition to SLI (e.g., Cohen, Vallance, Barwick, Im, Menna, Horodezky, & Isaacson, 2000). The distinction between SLI and autism is also not always easy to make as children with autism sometimes show the same language problems as children with SLI (Tager-Flusberg, 2004).

The figures for the prevalence of behavior problems among children with SLI widely range and appear to depend upon the manner in which the behavior problems are operationalized and the age of the children. In a recent study, the social-adaptive picture for a group of adult men who were known to have had SLI in their childhoods was examined. As much as 25% of the group was found to have behavior problems—both internalizing and externalizing— that reflects a psychiatric picture (Clegg, Hollis, Mahwood, & Rutter, 2005). Social behavior problems were found to occur among 50-70% of the 6-year old children with

SLI studied by Redmond and Rice (1998). In a recent study of children with SLI between the ages of 18 and 35 months, however, it was shown that early language development problems need not necessarily be accompanied by significant behavior problems. While the children displayed slightly more withdrawn behavior than children without SLI, the relation between SLI and behavior problems was the most strong when parents are raters. The difference between parents and teacher as raters diminished from kindergarten to second (Redmond & Rice, 2002). In the present study, the relation between language skill and behavior was also studied among a population of young children with SLI. In doing this, different aspects of the children's language skill were related to their behavioral profiles.

The present study

The present study involves a longitudinal study of young children with SLI in the Netherlands. The children were studied on three occasions with an intervening period of one year between the ages of four and six years. The examination of a typology of language skills was the most important research theme. However, in light of the recent international literature, the stability of the children's language skills and the relations of their language skills to aspects of their working memories and behavior were also studied.

The situation in the Netherlands

A key issue motivating this research was the lack of clarity regarding the classification of severe speech and language difficulties in the Netherlands. In the 1990s, the integration program *Together Again to School* [*Weer Samen Naar School*] was introduced in the Netherlands. One of the components of this program concerns the assessment of the need for special education. And along these lines, one of the primary objectives in the present research was to identify a classification system for children with clinically evidence SLI be used for special education assessment purposes.

The group of children selected for study in the present research all attended a special education school specifically for children with *severe* speech and language difficulties at the time of data collection. In the Netherlands, 30 such schools are distributed throughout the country. Children enter such a school when their language problems severely impair their ability to participate in mainstream education. Admission to such a school is determined by a multidisciplinary team of experts who check the request for help and determine if the child meets the admission criteria. The use of both clinical and psychometric criteria in classifying SLI justifies the composition of the target group for the present research with children from the aforementioned schools although we are very aware of the fact that the language picture at this young age can vary considerably (e.g., Bishop & Edmundson, 1987). Of the 110 four-year-old children who initially participated in the present research, 24 had left the study by

measurement occasions two or three because they no longer needed special education focused on their language problems.

Research questions

The present research concerns those factors that underlie the language problems of preschool-aged children with SLI in the Netherlands and the relations between their language skills, on the one hand, and their information-processing skills and behavior, on the other hand. The following research questions stood central.

1. What language factors can be distinguished for the research group?
2. How stable are the language skills of the children and what interrelations between the children's language skills can be identified?
3. How do cognition and working memory relate to the different language factors distinguished for the children?
4. What forms of problematic behavior are displayed by the children at the age of five years and do the different behavior problems relate to different types of language skills?

Methodological issues

In order to identify the relevant language factors for the target population, exploratory factor analyses were conducted. The results of the exploratory factor analyses were then taken as the starting point for confirmatory factor analyses and subsequently analyzed using a technique called structural equation modeling, which allows the researcher to combine factor analyses and multiple regression analyses (AMOS 5.0). In the present study, the multiple regression analyses were conducted to determine the relations between the different language factors across the different measurement points.

Outline of the dissertation

Four articles related to the four research questions outlined above and thus with their own focus constitute this dissertation. Three of the articles have either appeared or been accepted for publication in an international peer-reviewed journal. The fourth article is currently under review at an international peer-reviewed journal.

In Chapter 2, entitled *Subtypes of Severe Speech and Language Impairments: Psychometric Evidence from Four-year-old Children in the Netherlands*, the aim was to determine the extent to which different language factors could be distinguished for children with SLI and in keeping with current linguistic views. Exploratory factor analyses were undertaken for this purpose. Those professionals responsible for the children's speech and language therapy were also asked to judge the extent to which each child lagged behind in a number of language domains. These results were then correlated with the children's scores

for the identified language factors and, on the basis of these outcomes, a statement could be made with regard to the content validity of the language factors for the children with SLI.

In Chapter 3, entitled *Cognitive Predictors of Language Development in Children with SLI*, the aim was to determine the stability of the different language factors across measurement occasions and which interrelations between the language factors occurred on a given measurement occasion and across measurement occasions. For this purpose, confirmatory factor analyses were conducted. With the help of regression analyses, thereafter, just how the underlying language factors related to each other was examined in greater detail. The relations between the children's information-processing skills and the language factors were also examined at the same time.

In Chapter 4, entitled *Working Memory Limitations in Children with Severe Language Impairment*, the relations between working memory and language stand central. With the aid of structural equation modeling, those aspects of working memory that relate to the various aspects of the language skills of the children with SLI were examined in particular.

In Chapter 5, entitled *Behavior Problems in Children with Language Impairment*, the relations between SLI and behavior problems were examined with the aid of the Child Behavior Checklist. The parents of each child completed the checklist for their child with SLI for this purpose. Using structural equation modeling, the relations between the children's language skills and their behavior problems as indicated by the combined checklist scores from the mothers and fathers were then analyzed.

In Chapter 6, a number of conclusions are drawn with respect to the research questions, research objectives, and research results. The following themes are further considered in connection with the research results: sample issues, the language factors identified in light of recent theories about SLI, and the relation of cognitive problems and behavior problems with SLI. This final chapter is concluded with a discussion of some possible limitations on the present research and a number of the clinical implications of the present results.

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Chapter 2

Subtypes of severe speech and language impairments[1]

Abstract

Most, if not all, of the studies of subtypes of children with language impairments have been conducted with English-speaking children. The possibility and validity of identified subtypes for non-English clinical populations are, as yet, unknown. This study was designed to provide cross-linguistic evidence of language subtypes. A broad battery of tests was administered to measure the phonological, lexical, morphosyntactic, semantic, discourse, and pragmatic abilities of a representative sample of 110 4-year-old Dutch children who had been previously diagnosed as severely speech and language impaired. Principal components analyses revealed 4 subtypes of speech and language impairments, which were labeled *lexical–semantic, speech production, syntactic–sequential, and auditory perception*. These results were consistent with recent theoretical claims about the classification of English-speaking children with speech and language impairments.

Key words: subtypes, classification, severe speech and language impairments, speech disorders, language disorders.

Introduction

Speech and language impairments are generally accepted as constituting a category of problems with distinct features that separate them from other developmental problems (Beitchman et al., 1989; Bishop, 1994, 1999a; Bishop & Rosenbloom, 1987; Friel-Patti, 1999; Hall & Aram, 1996; Lahey, 1988; Plante, 1998; Rapin, Allen, & Dunn, 1983; Stark & Tallal, 1981; Tager-Flusberg, 1999; Tomblin, 1997). Speech and language impairments are also now included in such international classification systems as the fourth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (American Psychiatric Association, 1994) and *the International Classification of Functioning, Disability and Health* (World Health Organization, 2004). Children with a specific language impairment (SLI) are diagnosed as exhibiting a significant language production and/or comprehension deficit that cannot be explained by general cognitive impairment, sensorimotor deficits, frank neurological disorder, psychiatric diagnosis, or a general lack of exposure to language (cf. Leonard, 1989).

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The types of language problems that children can develop are very diverse, as recent studies of the classification and subtyping of such problems have shown. Unfortunately, the picture of the subtypes identified to date is far from clear, which may be due - at least to some extent - to the different classification methods used. In many of the studies, the number of participants is simply too small to identify statistically significant relations. In the vast majority of the studies, moreover, the measures do not cover the full range of relevant cognitive and linguistic abilities. And just which types of subtypes can be distinguished for which clinical populations has yet to be considered to any real extent. Most - if not all - of the subtyping literature also concerns strictly English-speaking samples, which means that the possibility and validity of the identified subtypes for non-English *clinical* populations are simply unknown; cross-linguistic research on the subtypes of language problems has yet to be undertaken.

In clinical practice, a number of people have tried to explain developmental language problems in terms of subtypes. One classic categorization has been put forth by Rapin and Allen (1983; Rapin, 1996) and is based on the classification of three main categories of developmental language disorder (DLD): mixed receptive/expressive impairments, expressive impairments, and higher order processing disorders. In the first category, a distinction is made between verbal auditory agnosia (i.e., central auditory processing problems) and phonological–syntactic deficits. In both cases, the impairment leads to problems with both language comprehension and language production. The second category includes verbal dyspraxia, which usually involves fluency problems and speech-motor deficits and thereby makes the organizational aspects of speaking particularly problematic. The third category includes lexical deficits, which can lead to word-finding problems, and semantic–pragmatic deficits, which can limit conversational skills. In the first study of DLD conducted by Rapin and Allen (1983), the subtypes were derived from (subjective) observations. In Rapin (1996), the subtypes were derived on the basis of a review of the classification literature.

In a number of psychometric studies, the empirical foundation for the current classification of speech and language impairments also has been examined. Aram and Nation (1975) were one of the first to investigate the specific patterns of language impairment within a population of children diagnosed as having developmental language problems. Investigation of the development of 47 children across a number of years revealed six specific patterns of language impairment (Aram, Ekelman, & Nation, 1984). In other research, Wolfus, Moscovitch, and Kinsbourne (1980) found only two main subgroups of children with SLI. However, their sample size was very small (N = 19), and the results of the two aforementioned studies are based on different quantitative measures of language proficiency. In other research, Wilson and Risucci (1986) combined clinical–inferential

information with quantitative information to classify 93 children with SLI and arrived at seven distinct subclasses of children with SLI. Here we miss adequate justification for the tests selected for inclusion in the test battery. Similarly, Haynes and Naidoo (1991) were able to cluster 156 children attending a special school for children with severe language disorders on the basis of their school records into nine distinct subgroups. However, the cases analyzed did not all have the same set of variables available. On the basis of spontaneous speech measures, Fletcher (1991, 1992) identified four subclasses of language impairment for a small group of 15 children.

The recent attempts by Conti-Ramsden (Conti-Ramsden & Botting, 1999; Conti-Ramsden, Crutchley, & Botting, 1997) to identify specific subgroups of language impairment using a large sample of participants, a standardized battery of language tests, and solid statistical analyses appear to be particularly promising. Their results support the existence of distinct subgroups of 7-year-old children with language problems along the following lines: (a) children who had good articulation skills but difficulties with syntax–morphology, receptive but sometimes also expressive; (b) children who have problems with phonology, expressive language, and poor word-reading ability; (c) children with articulation and phonology problems and expressive difficulties; (d) children with largely similar problems but overall higher profiles than those of cluster c; (e) children who performed poorly across all of the tests and appeared to have difficulties in all areas of language; and (f) children with semantic and/or pragmatic difficulties who were more likely to have receptive problems only. A follow-up study showed the subgroups to not be very stable across a period of 2 years, however.

The present study attempted to overcome the methodological flaws encountered in previous studies by administering a broad battery of theoretically relevant tests to a clinically identified population of children with severe speech and language problems. To measure the relevant phonological, lexical, morphosyntactic, semantic, discourse, and pragmatic linguistic abilities, the work of Bishop (1992) was taken as a starting point. When Bishop (1992) examined the most important theoretical efforts to explain the nature of SLI, six groups of studies could be distinguished according to the particular aspects of cognitive processing that they hypothesized to account for SLI. The hypotheses are as follows. (a) Underlying linguistic competence is intact, but processes involved in the conversion of this underlying knowledge into a speech signal are impaired. The problem is a pure output disorder. (b) Auditory perception is impaired, which impedes the course of language acquisition. (c) One or more specific linguistic mechanisms are impaired. (d) A general deficit in conceptual development is present and affects, but is not restricted to, language processing. (e) Learning strategies are abnormal, with a failure to apply appropriate hypothesis-testing procedures. (f) Limitations in the speed and capacity of the information-processing system cause language impairment. In the construction of the test battery for the present study, we

tried to take each of these hypotheses into account, and a 20-task speech–language test battery was the result. Principal components factor analyses were then undertaken to identify the theoretically relevant subtypes of speech and language impairment. To validate the detected subtypes, clinical observations on the same children were also undertaken and included as criterion variables. The following three research questions were then examined: (a) For which aspects of language do Dutch speech and language impaired children show developmental delays and to what extent? (b) Can different subtypes of Dutch speech and language impairments be empirically distinguished? (c) To what extent do clinical observations support the subtypes of Dutch speech and language impairments distinguished psychometrically?

Method

Participants

The participants were recruited from special schools for children with severe speech and language impairments in the Netherlands. In general, children are admitted to these schools only in the case of normal or low-average nonverbal intelligence, weak language scores on criterion-referenced tests (2 SD below the mean), no sensorimotor deficits, and no psychiatric disorder. An educational psychologist or a speech-language pathologist refers the children to such services after extensive clinical and psychometric examination. Admission must also be approved by an independent board, which checks the indication for admission.

Out of a total of 29 special schools, 24 proved willing to participate. A total of 110 four-year-old children (81 boys and 29 girls) were then randomly selected from these schools. A greater number of children were selected from the larger schools. The sample comprised about 50% to 60% of the total population of 4-year old children attending special schools for children with severe speech and language impairments in the Netherlands. Children with any apparent hearing problems (i.e., a loss of 30 dB or more in the best ear) were not included in the study. Bilingual children were also excluded. The parents of the children were asked to agree that their child participate in the study. At the time that the tests were administered, the mean age for the cohort was 53 months. The mean level of nonverbal cognitive development (measured via Raven's Coloured Progressive Matrices) corresponded to an IQ between 95 and 100.

Test Procedures and Measures

The children were tested in their own school environment. The regular speech-language pathologists administered the language tests. One of the researchers visited each school before test administration to explain the procedures and test administration. In some

cases, the schools requested assistance with test administration. In that case, a speech-language pathology student was sent to the school after extensive test training.

Table 1 contains an overview of the tasks included in the speech and language test battery. Some of the tasks were audiotaped to check the reliability of the test scores. All of the tests involved standardized procedures and have been shown to have sufficient content validity. The tests were selected to measure speech production, auditory perception, conceptual–lexical knowledge, and such specific linguistic capabilities as morphosyntactic proficiency, semantic development, and language information processing (speed and sequential processing). Some of the tests measure only one aspect of language proficiency, but others measure more than one aspect. Speech production was tested using the five speech dyspraxia tasks (DYS1 to DYS5) that constitute the Dutch battery used to test for "developmental apraxia of speech" (DAS; Maassen, 1999). Internal consistency was calculated by means of Cronbach's alpha (see Table 1). In addition, the articulation task from the Dutch test for language proficiency, the Taaltoets Alle Kinderen (TAK; Verhoeven & Vermeer, 2001), was administered to the children. All of the other language tasks from this test were also included in the present language test battery to measure the different aspects of language proficiency. Auditory perception was measured with two tests: the phonological discrimination (PD) test from the TAK and the Dutch experimental version of the Lindamood Auditory Conceptualization Test (LAC; Simkens, 1999; also see Lindamood & Lindamood, 1971; no reliability measures available). Aspects of verbal information processing were tested using the two sequential tasks from the German version of the Kaufman Assessment Battery for Children (Melchers & Preuss, 1991). The original American version of the test (Kaufman & Kaufman, 1983) shows Guilford's test–retest reliability coefficients of .85 and .83. Pragmatic language proficiency was measured using the Dutch experimental version of the Children's Communication Checklist (CCC; Bishop, 1998; Hartman et al., 1998). This checklist consists of 70 items distributed across nine categories. The scores for five of the categories (C to G) constitute the Pragmatic Composite score, which was adopted for use in the present study. Bishop (1998) has reported reliability coefficients of .74 to .88 for the different subscales.

To address the third research question, regarding clinical support of our findings, the judgments of two clinicians familiar with the child were gathered for each child. The child's teacher and the child's speech-language pathologist were asked to judge the articulation, the intelligibility, the receptive language ability, and the productive language ability of the children in the domains of morphology, syntax, the lexicon, and pragmatic language skills. For this purpose, a brief checklist was constructed, and the clinicians were asked to rate the capacities of the young children along a 4-point scale ranging from no problems (1) to very severe problems (4).

Table 1. Overview of the language battery.

Type of tasks	Abbreviation	Name of the task	Brief description of the task
Speech tasks	AT	Articulation task TAK* (α = .91) (Verhoeven, 2001).	Repetition of 45 short words covering all of the possible speech sounds in Dutch. Children have to complete all the items and reproduce them phonological correct (this scoring-procedure concerns all the speech tasks in the test-battery).
	DYS1	Picture naming* (α = .86) (Maassen, 1999).	Naming 8 pictures of normal objects, e.g. an airplane or a TV. Children have to name the object spontaneously. If they don't, the naming is elicited by an incomplete sentence.
	DYS2	Nonsense word repetition 1*(α = .76)	Repetition of 12 nonsense words, each containing 2 to 4 consonant-vowel-(vowel) syllables.
	DYS3	Word repetition 1* (α = .62)	Repetition of 10 words covering all of the vowels in the Dutch language.
	DYS4	Nonsense word repetition 2* (α = .82)	Repetition of 11 nonsense words, each word contains 3 consonant-vowel syllables, using only the vowel /a/. (e.g. 'sa-pa-da'.)
	DYS5	Word repetition 2* (α = .89)	Repetition of contrasting word-pairs matching pictures (15 items). The word pairs have a CVC-structure; pairs differ with respect to one of the consonants.
Language tasks	SC1 & SC2	Sentence comprehension tasks TAK 1 (α = .82) and task 2 (α = .86) (Verhoeven, 2001).	Comprehension of a sentence is measured by asking the child to look at three pictures and point to the correct picture (42 items, all administered). In SC1 the meaning of the sentence depends on key words in the sentence, in SC2 the order of the words in the sentence defines meaning.
	SR	Sentence repetition task TAK* (α = .95) (Verhoeven, 2001).	Repetition of elements of 20 long sentences. Correct repetition of function words and core sentence patterns is scored. Administration is stopped after 5 consecutive failures.
	WP	Word production task TAK (α = .83) (Verhoeven, 2001).	The child views a picture and hears an incomplete sentence in order to elicit word endings (24 items).
	NT	Narrative tasks TAK* (α = .90) (Verhoeven, 2001).	The child is presented a comic strip (8 pictures) and is asked to tell a story. The task contains two stories. Content (i.e., meanings and relations) is scored (as opposed to syntactic structures of the sentences).
	RV	Receptive Vocabulary task TAK (α = ..95) (Verhoeven, 2001).	The child is asked to point to one of four pictures after hearing a word (96 items; testing is stopped after 5 consecutive errors). Administration is stopped after 5 consecutive failures.
	PV	Productive Vocabulary task TAK (α = .90) (Verhoeven).	Naming of pictures (60). Testing is stopped after 5 consecutive errors.
	WD	Word Definition task TAK* (α = .88) (Verhoeven, 2001).	A pure verbal task, the child has to define words. Testing is stopped after 5 consecutive errors.
	SCT	Story Comprehension task TAK (α = .88) (Verhoeven, 2001).	Six stories are read aloud. After each story, four questions about the content of the story must be answered by the child.
Information processing tasks	WR	Word Recall Kaufman-ABC (Kaufman & kaufman, 1983).	Memory and recall of sequences of words. After hearing a sequence of words the child has to pint to corresponding pictures in the correct order. The number of words to be recalled increases. Testing is stopped after 3 consecutive errors or at the age ceiling.
	DS	Digit Span Kaufman-ABC (Kaufman & kaufman, 1983).	Repetition of sequences of digits heard. The number of digits to be recalled increases Testing is stopped after 3 consecutive errors or at the age ceiling.
Auditory perception tasks	LAC	Dutch experimental version of the Lindamood Auditory Conceptualization test. (Simkens, 1999).	The child must reproduce sequences of phonemes by matching a specific color with a phoneme and placing blocks in the correct order (maximum score is 28; part 1 has 16 items and all items are administered; part 2 has 12 items and testing is stopped after 5 consecutive errors).
	PD	Phonological discrimination task TAK (α = .96). (Verhoeven, 2001).	The child has to listen to pairs of words and tell if they are the same or not (50 pairs: 37 different and 13 identical), all items are administered. The word pairs differ with respect to one phoneme.
Children's communication checklist	CCC	Pragmatic composite scores (C-G) (Hartman e.a, 1998)	C: Inappropriate initiation D: Coherence E: Stereotyped conversation F: Use of context G: Conversational rapport

Note. TAK = Taaltoets Alle Kinderen; K–ABC = Kaufman Assessment Battery for Children. ·:Task was audiotaped.

Data Analysis

The data were analyzed using SPSS 10.0.5. The data on the PD task showed 41 missing values. These were replaced using the nearest neighbor method, which involves the use of other receptive language tasks as the neighbor in this case. The seven missing values for the other variables were excluded from the factor analysis. The data for children showing clear behavioral problems during testing and therefore refusing to either take or finish one or more of the tests were excluded from the database.

With regard to the first research question, t-tests were conducted to examine the differences between the performance of the children with severe speech and language impairments and the performance of normally developing children on the various tests. The correlations between the various language test scores were next calculated, and factor analyses were conducted to address the second research question. A principal components analysis with varimax rotation was conducted. The eigenvalue was set at >1.0. The identified factors were next saved as variables for the individual children. By doing this, the identified factor variables could be correlated with the clinical judgments provided for the children, and this information could be used to answer the third research question.

Results

Descriptive Statistics

The scores for the 4-year-old children on the different tests/tasks were found to be normally distributed in most cases. Exceptions were the sentence reproduction (SR) task, which seemed to be very difficult for the children in our sample (skewness 2.058 and kurtosis 4.424) and the word definition (WD) task (skewness 1.136 and kurtosis 1.647). The means and standard deviations for the tasks administered to children with severe speech and language impairments and the available normative samples are presented in Table 2. T-scores, obtained with Bonferroni adjustment, were computed to examine the differences between the clinical and normative samples. In this study, 14 pairwise comparisons were made. For any comparison to be considered significant, the optained p-value has to be less than .00357. This proved to be the case for all comparisons made. The norms for a 4-year old group of children were not available for the productive vocabulary (PV) task, so the norms for the 5-yearold group of children were adopted for reference.

Inspection of the results in Table 2 shows the answer to the first research question to be that the children in our study displayed considerable developmental lags on many of the language tasks. The results for the speech dyspraxia tasks (DYS1 to DYS5) were not included in Table 2 because the norms for these tasks are not as yet available.

Table 2. Mean raw scores for sample and normative samples.

	Study sample		Normative sample		
Task	Mean	SD	Mean	SD	T-score
Speech [a]					
AT	17.20	12.02	41.26	5.13	-33.15***
Language					
SC1	21.14	7.05	27.05	5.71	- 9.40***
SC2	20.36	7.94	25.17	6.34	- 6.86***
SR	4.48	6.49	19.69	11.46	-13.45***
WP	5.47	4.00	11.36	4.23	-13.35***
NT	6.64	5.43	10.51	6.62	- 5.72***
RV	29.83	11.90	42.53	14.07	- 8.80***
PV	14.91	7.51	31.85[b]	8.2[b]	-21.73***
WD	3.54	3.34	10.69	5.96	-12.16***
SCT	8.24	5.70	12.18	5.65	- 6.61***
Inf. Processing					
DS	6.03	2.42	10.00	3.00	-12.98***
WR	8.34	1.92	10.00	3.00	- 5.56***
Auditory perc. [a]					
PD	28.40	7.46	36.55	9.67	- 8.31***
CCC	137.39	10.38	153.68	6.49	-10.65***

Note. N = 110 for sample studied; N = 500 for normative samples and TAK tasks.

[a]No norms for the Speech Dyspraxia tasks or the LAC available. [b]Norms for 5-year-old children used for comparison.

***p < .00357.

The speech dyspraxia tasks were nevertheless constructed on the basis of generally accepted knowledge regarding the linguistic proficiency and performance of normally developing 4-year old children. This means that the many errors made by the children in our study can be attributed to a severe delay in the domain of speech articulation. The scores of the children studied here on the CCC were compared with those of children with SLI studied by Bishop and Baird (2001). Scores and distribution seemed to be largely similar.

Correlations and Factor Analyses

The intercorrelations between the scores of the children on the different tasks are presented in Table 3. As can be seen, the speech tasks showed medium-to-large correlations with almost all of the other language tasks. This suggests that the scores on the other language tasks and speech production problems encountered by the children were associated with each other. Almost all of the language tasks showed medium-to-large intercorrelations.

Table 3. Correlations between the scores of the children in this study on the different speech- and language tasks.

	AT	DYS1	DYS2	DYS3	DYS4	DYS5	SC1	SC2	SR	WP	NT	RV	PV	WD	SCT	DS	WR	PD	LAC	CCC
Speech																				
AT	1.00																			
DYS1	.69	1.00																		
DYS2	.44**	.63**	1.00																	
DYS3	.57**	.72**	.72**	1.00																
DYS4	.68**	.63**	.60**	.71**	1.00															
DYS5	.43**	.49**	.52**	.56**	.45**	1.00														
Language																				
SC1	.10	.27**	.31**	.29**	.18	.46**	1.00													
SC2	.20*	.29**	.39**	.36**	.30**	.41**	.83**	1.00												
SR	.23*	.35**	.43**	.53**	.49**	.45**	.42**	.41**	1.00											
WP	.32**	.39**	.42**	.45**	.37**	.35**	.45**	.50**	.37**	1.00										
NT	.36**	.38**	.39**	.42**	.37**	.51**	.40**	.41**	.51**	.43**	1.00									
RV	.09	.34**	.31**	.27**	.09	.27**	.55**	.51**	.35**	.48**	.41**	1.00								
PV	.31**	.46**	.30**	.38**	.31**	.48**	.58**	.55**	.38**	.62**	.50**	.56**	1.00							
WD	.22*	.34**	.20*	.45**	.21*	.42**	.44**	.45**	.40**	.47**	.57**	.47**	.49**	1.00						
SCT	.13	.33**	.26**	.34**	.21*	.39**	.65**	.69**	.49**	.53**	.51**	.55**	.66**	.57**	1.00					
Information processing																				
DS	.20*	.28**	.31**	.36**	.40**	.20*	.44**	.48**	.38**	.26**	.18	.29**	.38**	.09	.37**	1.00				
WR	.13	.22*	.19	.34**	.22*	.33**	.35**	.46**	.39**	.27**	.27**	.29**	.29**	.21*	.30**	.53**	1.00			
Auditory perception																				
PD	.09	.18	.26*	.29**	.10	.27*	.36*	.43**	.25*	.33**	.21	.29*	.31**	.17	.35**	.17	.28*	1.00		
LAC	-.04	.11	.23*	.23*	.06	.14	.21*	.12	.33**	.31**	.24*	.25**	.20*	.23*	.26**	.12	.13	.25*	1.00	
CCC	-.18	-.05	-.01	-.01	-.04	.01	.26**	.17	.16	.23*	.10	.36**	.22*	.10	.23*	.16	.18	.21	.15	1.00

* = p < .05, two-tailed. ** = p < .01, two-tailed.

The two auditory perception tasks (PD & LAC) showed medium correlations with the word production (WP) task and the story comprehension task (SCT). However, the two vocabulary tasks, receptive vocabulary (RV) and PV, the sentence comprehension tasks (SC1 & SC2), and the sentence reproduction task (SR) showed a medium correlation with one of the auditory perception tasks as well. This suggests that the auditory perception skills of the children and their capacity to comprehend and produce both words and sentences influence each other. The two informationprocessing tasks concerned with sequential processing, Digit Span (DS) and Word Recall (WR), showed medium-to-large correlations with SC1 and SC2 and SR, but also with the word definition (WD) and vocabulary tasks, receptive vocabulary (RV) and PV. The few and only medium correlations of the Pragmatic Composite score for the CCC with the other linguistic measures suggest that pragmatic language problems constitute a distinct category of problems (Bishop & Norbury, 2002). These results show many language skills, or, in fact, the problems associated with the development of various language skills to be clearly associated with each other.

Factor analyses were undertaken to answer the second research question. The results are presented in Table 4 and show 65% of the total amount of variance to be explained by the four rotated factors, which is a satisfactory finding. As can be seen, the first and second factors explain about 20% of the total variance each, while the third and fourth factors explain about 10% of the total variance each. When we attempted to search for additional factors to explain more of the variance, the factor structure became so mixed up that theoretically plausible explanations became difficult to find.

Table 4. Total variance explained by the factor analysis.

Factor	*% of Variance*	*Cumulative %*
1	22.05	22.05
2	21.10	43.14
3	11.07	54.21
4	8.76	62.97

The factor analysis results are presented in Table 5. As can be seen, the first factor consists of tasks with word knowledge and story telling as the key skills. It thus appears that word knowledge, the ability to use words, and proficiency with the understanding and production of sentences and stories constitute a single subtype of language deficiency. The second factor consists in part of tasks that measure the correct pronunciation of words. That is, correct articulation and good intelligibility are the key skills. The other three tasks that load on this factor are the more complex productive language tasks. In other words, the articulation problems encountered by young children with severe speech and language impairments appear to impair their performance on these latter tasks as well.

Table 5. Results of factor analysis on speech and language tasks.

TASK	*Factor 1*	*Factor 2*	*Factor 3*	*Factor 4*
Speech				
AT		**.81**		
DYS1		**.81**		
DYS2		**.74**		
DYS3		**.84**		
DYS4		**.84**		
DYS5		.59		
Language				
SC1	**.71**		.43	
SC2	.68		.50	
SR	.41	.43	.30	.41
WP	.58	.34		
NT	.62	.39		
RV	.66			.32
PV	**.74**			
WD	**.77**			
SCT	**.79**			
Inf. Processing				
DS	.31		**.84**	
WR			.67	
Auditory perc.				
PD				.64
LAC				**.75**
CCC				.49

Note. Eigenvalues > 1.0; cases containing missing values deleted pairwise. Varimax rotation solution. Values > .30 reported.

The third factor consists of the two sentence comprehension tasks and two tasks requiring the reproduction of sequential auditory information. Receptive grammar and aspect of auditory processing and/or memory are important here. The fourth and final factor consists primarily of the two auditory perception tasks and the Pragmatic Composite score for the CCC. The discrimination of speech sounds plays an important role in the two auditory perception tasks: the LAC and the PD. Some other tasks also loaded on this factor. Both the RV task and the SR task also loaded on this factor, for example.

Test Outcomes and Clinical Judgments

The third research question is an important one in the light of the ongoing discussion of the merits of quantitative versus qualitative measurements of language impairment. More specifically, the issue is whether the distinct subtypes of severe speech and language impairments distinguished using psychometric methods can be confirmed clinically.

In Table 6, the correlations between the four subtypes of language deficiency revealed by the factor analyses and the checklist ratings provided by the clinicians for the individual children are presented.

Table 6: Pearson's correlation coefficients for language factors with clinical judgments.

	Factor 1		Factor 2		Factor 3		Factor 4	
	SLP	T	SLP	T	SLP	T	SLP	T
Articulation	-.10	.07	.59**	.47**	-.08	.05	-.09	-.10
Intelligibility	.44**	-.03	.72**	.47**	-.14	.06	.03	.09
Language understanding								
Morphology	.48**	47**	.04	.06	.23*	.24*	.40**	.19
Syntax	.50**	60**	.06	-.04	.18	.28*	.37**	.17
Lexicon	.10	56**	.02	-.04	.16	.38**	.39**	.13
Language production								
Morphology	.18	.16	.26*	.36**	.28*	.18	.42**	.21
Syntax	.41**	.23*	.31**	.35**	.21	.28*	.38**	.28*
Lexicon	.46**	.44**	.16	.07	.12	.28*	.44**	.29*
Pragmatic lang.	.17	.11	-.13	.11	.19	.04	.16	.11
Attention	.17	.18	-.03	-.02	.18	.15	.41**	.33**

Note. SLP = speech-language pathologist; T = teacher.

*p < .05. **p < .01.

As can be seen, the first factor (i.e., subtype of language deficiency) shows large correlations with all of the checklist items addressing language understanding. Medium correlations are found between the subtype of language deficiency and language production (syntax and lexicon). The individual correlations between the various speech and language tasks and clinical judgments are not presented here, but we can report large correlations of .50 for both the receptive and productive vocabulary tasks with most of the relevant judgments from the speech-language therapists and the teachers. Correlations of .40 to .50 were also found for SC1, SC2, and SCT, on the one hand, and the clinical judgments regarding the lexicon. The second factor shows large correlations with those checklist items addressing articulation and intelligibility. Medium correlations with judgments concerning the morphological and syntactic production skills of the children also were found. Medium correlations of .40 were found for Tasks 3 and 4 with judgments of articulation and intelligibility. For the third factor, only one medium correlation was found for the impressions of the teacher regarding the lexical production abilities of the children in question. The checklist scores provided by the teachers showed a greater number of small and only slightly

significant correlations at the <.05 level with both the language understanding and language production aspects of the third factor. The individual correlations showed almost all of the language variables to generate medium-to-high correlations with the judgments of syntactic understanding, which suggests that the syntactic judgments were very difficult for both judges to make. Finally, the fourth factor shows medium-to-large correlations with all of the language impressions provided by the speech-language pathologists but only two small-to-medium correlations with the impressions provided by the teachers for language production. The individual correlations between the variables that constitute Factor 4 and the clinical judgments are in most cases low and only slightly significant. Medium correlations with the clinical judgments of the attention skills of the children were also found for the fourth factor.

Discussion

The current study was undertaken to provide cross-linguistic evidence of language subtypes. Young Dutch children visiting schools for severe speech and language impairments were tested using a broad battery of speech-language tests, and clinical judgments were gathered.

The data were used to answer three research questions. First of all, we were interested for which aspects of speech–language and to what extent Dutch speech and language-impaired children showed developmental delays. Even when we used a conservative t-test for the significance of difference among means, the data showed that the children in our research sample had significantly lower scores on all the speech–language tests administered. Such significance was also obtained because of low standard deviations and large samples. The children in our sample had very low scores on the articulation task. This finding was congruent with other research in clinical samples of young children (Bishop & Leonard, 2000; Law, Boyle, Harris, Harkness, & Hye, 2000). Other tasks showing impressive developmental lags were the vocabulary tasks and the WD, on the one hand, and the SR and WP tasks, on the other hand. Finally, the children in our sample had much lower scores on the DS, a task testing information processing and, more specifically, auditory sequential working memory.

As an answer to the second question, we found different subtypes of Dutch speech and language impairments. This finding was in line with recent emperical research on children with SLI (Botting & Conti-Ramsden, 2004) as well as with recent theoretical and diagnostic insights (Bishop, 2004). These findings are also important in gathering cross-linguistic evidence for the existence of subtypes of speech and language problems.

Our third question concerned the extent clinical observations would support the subtypes found. The first two factors were validated by the clinical judgments of teachers and speech-language pathologists. The other factors showed a more diffuse pattern of

correlations with clinical judgments. In the next section, the four subtypes of language impairment are considered in greater detail.

The Subtypes of Language Impairment in a Dutch Population

In the sections above, it was shown that four subtypes of severe speech and language impairment could be distinguished by means of a battery of psychometrically validated language tests. In this section, we attempt to label these subtypes in a theoretically and clinically relevant manner. To do this, the tasks that load on a particular factor are examined in greater detail, and the results of other classification studies conducted within this domain are considered to find a suitable label.

Looking at the tasks that constitute the first factor, one could argue that this factor reflects a global receptive–expressive language impairment. However, closer examination of the language tasks loading on this factor shows them all to require the understanding or expression of meaning (i.e., the semantic information conveyed by words and sentences). Given that the children studied here have severe language problems and are relatively young, it is possible that the lexical skills (i.e., word knowledge and word-finding skills) of some, if not many, of the children are very poor and may actually constitute the primary cause of their problems with the understanding and expression of meaning. The relevant language skills mentioned here are typically referred to as semantic language skills (Bishop, 1999b). Because there seems to be clinical validation that this factor reflects early lexical skills, we decided to label the first factor the Lexical–Semantic factor or subtype of language impairment. The Lexical–Semantic factor was found to explain about 22% of the variance observed in the children's test scores. For young children with severe speech and language impairments, the building of a lexicon appears to be a critical skill and perhaps the most important skill for the early understanding and production of meaning. Rapin (1996) and Rapin et al. (1983) also identified a lexical–semantic subtype of developmental speech and language impairments in their clinical survey. That is, a specific group of children was found to have severe word-finding difficulties, problems with the understanding of connected speech, and problems with the utterance of language on command. Note that both receptive and productive problems were found to characterize the Lexical–Semantic subtype of language impairment. This finding has strong repercussions for the separation of receptive disorders from expressive disorders, as suggested by Wolfus et al. (1980) and Wilson and Risucci (1986). In addition to this, some of the tasks that load on the first factor also load on the third factor, which brings us to the interdependence among some of the factors (i.e., various subtypes of language impairment). Impairment of one type of skills may imply impairment of another type, and these interconnections should thus be taken as the starting point for further examination of the possible causal relations among the different subtypes of

language impairment. Along these lines, Bishop (1999b) also described the interdependence of different causal factors for the explanation of language-understanding problems.

The tasks that constitute the second factor are all productive in nature. The six tasks loading highest on this factor all concern the articulation of words, nonsense words, or phonological contrasts. A subtype of speech–language impairment related to articulation skills has been frequently mentioned in other classification studies. For example, Aram and Nation (1975) have mentioned a nonspecific formulation–repetition disorder in addition to a speech-programming disorder; Wolfus et al. (1980) have mentioned syllable production problems; and Rapin et al. (1983) and Rapin (1996) specifically have mentioned a phonologic production/verbal dyspraxia disorder and a speech planning/programming disorder. The first disorder mentioned by Rapin and colleagues involves children with very poor phonology and extreme dysfluency; the second disorder involves incorrect pronunciation of words due to planning problems. Given that the factor loadings in the present study point to problems on all of the articulation tasks, a distinction between the problems caused by poor phonology, poor motor/articulation skills, or poor programming skills cannot be made. We therefore decided to assign the label Speech Production to the second subtype of language impairment identified here. The fact that three other productive tasks, which load on the first factor, also load on this second factor suggests that poor articulation skills may directly influence children's performance in the domains of word production, sentence reproduction, and narrative production. Such poor performance can be attributed to poor intelligibility, but the children being tested may also be painfully aware of their speech output problems and thereby simply refuse to complete the relevant tasks. We tried to control for this behavioral factor by excluding children with 0 scores on the speech tasks due to refusal from our sample. Cluster analysis showed that speech production problems and low expressive language performance appear together in about one third of the sample (Clusters 4 and 5).

The tasks that constitute the third factor involve two specific skills. The first skill is understanding the meaning conveyed by a complex sentence in which the arrangement of the words, their inflections, and the use of function words are essential. The second skill is auditory sequential processing, as measured by two Kaufman Assessment Battery for Children tasks, namely, the DS and WR tasks. Along these lines and to explain the relation that is often observed between sequential processing abilities and receptive grammatical development, Leonard (1989) has put forth the "surface hypothesis" and has argued that processing problems may actually be the cause of many grammatical problems. Morphemes that are not salient, not stressed, or short in duration are vulnerable to omission and reduction. When a child has poor sequential processing abilities and cannot simply memorize all of the features of a sentence as it is heard, the nonsalient features are obviously most at

risk for not being heard, processed, or memorized. However, small bits of morphological information can radically change the meanings of both words and sentences, and a failure to process these bits of information can therefore lead to comprehension problems. Given the putative connection between sequential auditory processing problems and language comprehension problems, it was decided to assign the label of Syntactic–Sequential to the third subtype of language impairment. Along these lines, the possible existence of a grammatical subtype of language impairment has been the topic of many recent studies. In classification studies, however, only the most recent publication by Rapin (1996) mentions the possibility of such a subtype of impairment. The fact that the sentence comprehension tasks in the present study loaded on both the first and third factors (i.e., subtypes of language impairment) suggests alternative explanations of poor performance on these tasks. In other words, the poor performance of young children on sentence comprehension tasks may be caused by information-processing problems, a specifically linguistic inability to understand sentences, conceptual problems, and/or purely lexical problems. Further study is clearly needed to map the relations among these various aspects of children's functioning and the directions of causality relating to impairment.

The tasks that constitute the fourth factor are diverse and make it difficult to construe the pattern of performance as characterizing a specific type of language impairment. The PD task and the LAC task loaded highly on this factor. The other three tasks with high loadings on this factor were the RV task, the SR task, and the Pragmatic Composite performance on the CCC. The clinical judgments of both poor receptive and poor productive language skills correlated with the fourth factor, and a significant correlation with the children's attention skills also was found. Furthermore, the fourth factor did not show significant correlations with clinical judgments of pragmatic language problems, which again suggests that pragmatic language problems constitute a distinct category of problems for children with language impairments and are not easily found using psychometric testing. While impaired auditory perception may constitute an independent impairment, it may also be the result of attention deficits. That is, when auditory information is not processed sufficiently, difficulties with the correct interpretation of sounds, syllables, words, and different speech segments may obviously arise. Recall and comprehension problems may then occur, and auditory processing difficulties can thus be seen as a major risk factor for the development of severe language difficulties (Bishop, 1992). Given that the majority of the tests/tasks loading significantly on the fourth factor measured auditory processing, however, it was decided, for the present, to assign the label Auditory Perception to this factor or subtype of language impairment. In support of this, auditory perception problems are commonly mentioned in classification studies (Rapin, 1996; Rapin et al., 1983; Wilson & Risucci, 1986).

With regard to the aforementioned typology as a whole, the following conclusions can be drawn. The first conclusion is that we indeed found theoretically relevant subtypes of language impairments within a clinical population of children with severe speech and language impairments. Perhaps more important, these subtypes of impairment were found for children learning a language other than English, namely Dutch, and thus provide cross-linguistic evidence for the existence of specific subtypes of developmental language problems.

Limitations.

While empirical evidence was found for the existence of at least four subtypes of language impairment within a population of Dutch children with severe speech and language impairments and theoretically relevant labels for the different subtypes could be found, some limitations of the present study also nevertheless exist. First, the generalizability of our findings to other groups of children with severe developmental language difficulties and children with SLI remains unclear. The focus of the current study was on children with severe speech and language impairments attending special schools in the Netherlands. However, there are many children with moderate-to-severe speech and language impairments attending regular schools, and some of these receive speech and language therapy and/or remedial teaching, while others do not. While the latter group of children was not considered in the present study, additional investigation of mainstream populations using the same battery of tests and procedures may nevertheless help us validate the results of the present study further.

Second, the selection criteria used in the present study did not cover all of the exclusion criteria formulated by Stark and Tallal (1981) for the selection of SLI participants. That is, the children included in the present study were diagnosed and classified as severely language impaired on the basis of the strict indication criteria and test procedures followed by special schools.

A third possible limitation is the inclusion of only a sample of 4-year-old children. The applicability (i.e., generalizability) of our conclusions and typology of early language impairment to other age groups are therefore unknown. The possibility of developmental changes in the typology of language difficulties (e.g., the fading of speech articulation difficulties accompanied by a shift to other language difficulties) cannot be ruled out. Along these lines, the results of the study reported by Conti-Ramsden and Botting (1999) suggest that the typology and classification of children with SLI may, indeed, not be stable over time. In other words, the specificity and appearance of the difficulties encountered by children with developmental language impairments may evolve during the course of their school careers. For this reason, subsequent studies using the same sample of children will be undertaken to

examine the stability of the four subtypes of language impairment over time. Children may move from one subtype of language impairment to another, and in such cases, insight into the longitudinal patterns of change will be needed.

A final possible limitation on the present study lies in the fact that the subtypes of language impairment identified here are based on standardized elicitation tasks and test scores. A first attempt to validate the findings using clinical judgments showed some clear correlations between the subtypes of language impairment identified using the test battery and the clinical judgments of both teachers and speech-language pathologists. Nevertheless, more extensive validation is needed to build a stronger case.

Implications for Actual Practice and Future Research.

The current study has important implications for clinical practice, educational practice, and future research. The specific subtypes of severe language impairment identified here in a Dutch sample resemble the subtypes identified for children with developmental language problems in English-speaking samples. More specific knowledge of the types of language impairment being experienced by a particular child can certainly improve specification of the goals for intervention purposes and help guide the remedial teaching efforts. In addition, a typology of language impairments can help predict the outcomes of remediation programs and thereby the evaluation of such programs.

The identification of distinct subtypes of language impairment can also lead us to reexamine the language tests and screening procedures currently in use. Much more specific tests and subtests may be selected and developed for both diagnostic and screening purposes. And in such a manner, it will become possible to determine not only a developmental language delay but also the exact nature of the delay.

The validity of the subtypes of language impairment identified here may be strengthened with the conduct of further psychometric testing in conjunction with the collection of clinical impressions. Finally, spontaneous speech samples from children with language impairments have to be analyzed for the presence of a similar typology of language impairments as postulated here.

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Chapter 3

Cognitive Predictors of Language Development in Children with SLI[1]

Abstract

Background: Language development is generally viewed as a multifactorial process. There are increasing indications that this similarly holds for the problematic language development process. **Aims:** In the present study, a population of 97 young Dutch children with Specific Language Impairment (SLI) was followed over a 2-year period to provide additional evidence for the existence of underlying language factors. Furthermore, the children's language development was related to their nonverbal intellectual reasoning capacity. **Methods & Procedures:** The language abilities were assessed via administration of an extensive battery of language tests, cognition via administration of the Raven progressive matrices and short-term memory capacity via administration of a digit span task. **Outcomes & Results:** The results provide empirical support for distinct language factors for children with language problems. The detected factors were labeled: phonology, lexical-semantics, syntax, and speech production, and were found to be stable and interrelated. Short-term memory showed strong relations with the language factor syntax and medium relations with the other language factors. Intellectual capacity, showed weak to medium relations with three language factors but no relation with the factor speech. **Conclusions and Implications:** The language development of children with SLI appears to be highly similar with the language development of non-SLI children with respect to the components and also their interrelations. There are relative differences in strengths of certain language factors and the interrelations between SLI and non-SLI. Secondly short-term auditory memory plays an important role in the language acquisition of children with SLI. It is recommended that children with SLI should be assessed on possible deficits in information processing and/or short term memory. Existence of such deficits calls for specific neuropsychological intervention.

Key words: longitudinal, language factors, cognitive predictors, SLI.

Introduction

For the last few decades the language problems of children have constituted important domains for research, education, and treatment. One speaks of specific language impairment (SLI) when the language problems are not caused by clear external factors such

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as hearing loss, neurological damage, emotional neglect or trauma. It is generally concluded for children who acquire language conventionally that the language development includes separate but related components such as phonology, lexicon/semantics, syntax, pragmatics, and speech (see Hoff & Shatz, 2007). For children with language problems, several studies also show that different language factors can be distinguished. There is clinical evidence for mixed receptive/expressive impairments (i.e., verbal auditory agnosia and phonological-syntactic deficits), expressive impairments (i.e., verbal dyspraxia and speech-motor deficits), and higher-order processing disorders (i.e., lexical deficits that can lead to word finding problems and/or semantic-pragmatic deficits), (Rapin, 1996). Moreover, different subtypes of language problems were distinguished on the basis of a psychometric test battery (e.g. Haynes & Naidoo, 1991). In all of these cases, however, only a small number of children were involved and the selection of the measurement instruments had a weak theoretical basis. A rather promising initiative using a large sample of children and a standardized test battery that showed theoretically well-grounded subtypes can be found in the studies by Conti-Ramsden and colleagues (e.g., Conti-Ramsden & Botting, 1999). However, in their follow-up study conducted two years after the initial study, the same subtypes of language problem were identified but the child subgroups did not prove stable: 45% of the children were assigned to a different subgroup. Another major attempt concerns two cross-sectional studies in the Netherlands in which four underlying language factors were consistently identified for young children with SLI between the ages of four and ten years: phonology, lexical-semantic problems, syntactic problems and speech problems (van Daal, Verhoeven & van Balkom, 2004; van Weerdenburg, 2006).

An important question is to what extent language problems can be predicted from a child's cognitive development. From a theoretical perspective, the emergence of language problems is often viewed as independent of cognitive problems when cognition is operationalized as the degree of intelligence. It is then assumed from such a perspective that a statistically significant discrepancy between nonverbal IQ and verbal IQ should be found to speak of "specific" language problems (e.g., Stark & Tallal., 1981). The validity of this assumption has been increasingly questioned, however, as a discrepancy between nonverbal and verbal IQ is not always discerned for children with clearly clinical language problems (e.g. Krassowski & Plante, 1997). In current psycholinguistic models of language processing, it is assumed that cognitive and language processes are closely related (e.g Bishop, 1997). Recent neurobiological studies have provided evidence that speaking and comprehending language involves the efficient retrieval of word information from memory along with the employment of unification operations to combine words into larger units by relating semantic, syntactic and phonological levels of processing (see Hagoort, 2005). Viewed in such a manner, general information-processing problems can sometimes

characterize children with language problems (e.g., Gillam, 1997). And there is also considerable evidence that short term memory plays an important role in language development and that a limited short term memory capacity can lead to language problems (e.g. Gathercole, Tiffany, Briscoe, & Thorn, 2005).

The present study aims to uncover the role of cognitive factors in language development in 5- to 6-year-old children with SLI in the Netherlands. In operationalizing language development an attempt was made to overcome the methodological flaws encountered in previous studies by administering a broad battery of theoretically relevant tests to a clinically-identified population of children with SLI. As the developmental picture of the language system is an interactive and changing one, it was decided to follow the language development of children with language problems for one year and to carefully map those language modalities which are delayed along with the influence of the different modalities on each other and the relation with developing cognitive processes during the course of language development (e.g., Weismer & Evans, 2002). Two measurement occasions were employed to investigate the children's language profiles and language development, with one year in between the measurements. A wide range of language tests was administered on both occasions. On each occasion, separate language factors were searched for and the predictive value of intellectual capacity and short term auditory memory on these factors was examined. The following research questions were addressed:

1) For which aspects of language do Dutch speech and language impaired children show developmental delays and to what extent?
2) Which language factors can be distinguished on the two measurement occasions and to what extent are the detected language factors found to be stable in time?
3) To what extent do intellectual capacity and short term auditory memory predict children's language development?

Method

Subjects

The children in the research sample were selected from a population of children enrolled in a special education program aimed at children with auditory and/or communication problems in the Netherlands. The children enrolled in such a program have SLI. Placement in such a school is based on a delay of two or more standard deviations on a language screening test and clear educational limitations due to communication problems. Permission for the children to participate in the present study was obtained from the children's parents. The children in the sample had at least a nonverbal IQ greater than 70, no peripheral hearing problems, no obvious neurological problems, and no autism. The children were an average of five years and four months upon initial language measurement, and a

total of 97 children were studied (72 boys, 25 girls). The children were randomly selected from all of the preschool children in the special schools; the larger the school, the greater the number of children selected for inclusion in the study. Cognitive tasks were administered at the age of four. The children were assessed using the same battery of tests one year after initial assessment. A total of 84 children (87% of the original sample) were assessed after one year, the average age of the children at this time was six years and four months. On measurement occasion two, there were 13 drop-outs who had progressed to a mainstream educational program. When the test battery results for the drop-outs on measurement occasion one were compared to the results for the entire research group on measurement occasion one, the means and standard deviations for the two groups on all of the tasks were found to be quite comparable. The group of children who dropped out of the study was thus not atypical of the group of children constituting the research group.

Instruments

All of the language tasks involved standardized procedures and have been shown to have sufficient reliability and content validity in terms of the Cronbach's alphas. When available, the alphas are reported for each task. The tasks were selected to measure speech production, phonology, lexical-semantic knowledge, and syntactic proficiency as these are the major language modules mentioned in the literature on language development and language disorders (e.g., Bishop, 1997; Reed, 2005). The tasks used in the present study were selected from a broader battery of tests using exploratory factor analyses and theoretical information (van Daal et al., 2004).

Speech production was assessed using two tasks from the Dutch experimental dyspraxia battery (Maassen, 1999) and, in addition, the articulation task from a Dutch test of language proficiency (Taaltoets Alle Kinderen (TAK), Verhoeven & Vermeer, 2001). The first Dyspraxia task was "picture naming" (Dys1, α = .86) and required the child to name eight pictures of common objects (e.g., an airplane, a TV). The child had to spontaneously name the relevant object. If the child did not do this, a naming response was elicited using an incomplete sentence. The second Dyspraxia task was "word repetition" (Dys 2, α = .62) and required the child to repeat 10 words covering all of the vowels in the Dutch language. The Articulation task (AT, α = .91) required the child to repeat 45 short words covering all of the possible speech sounds in the Dutch language. The child had to reproduce all of the items phonologically correctly. Phonology was measured using the phonological discrimination test from the Dutch TAK and the experimental Dutch version of the Lindamood Auditory Conceptualization Test (Simkens, 1999). On the Phonological Discrimination test (PD, α = .96), the child had to listen to pairs of words and state if they were the same or different (50

pairs: 37 different; 13 identical; and all administered). The word pairs differed with respect to one phoneme. On the Dutch version of the Lindamood Auditory Conceptualization Test (LAC), the child had to reproduce sequences of phonemes by matching a specific color block to a phoneme and placing the blocks in the correct order (maximum score of 28; part 1 had 16 items and all items were administered; part 2 had 12 items and testing was stopped after five consecutive errors). Lexical-semantic knowledge was tested using four tasks from the Dutch *TAK* test. On the Receptive Vocabulary task (RV, α = .95), the child had to point to one of four pictures after hearing a word (96 items; testing stopped after five consecutive errors). On the Productive Vocabulary task (PV, α = .90), the child had to name 60 pictures and testing was stopped after five consecutive errors. On the Word Production task (WP, α = .83), the child viewed pictures and heard incomplete sentences in order to elicit word endings (24 items). Finally, the Word Definition task (WD, α = .88) is a purely verbal task and required the child to define words (45 items). Once again, testing was stopped after five consecutive errors. Syntactic proficiency was assessed using two Sentence Comprehension tasks (SC1, α = .82; SC2, α = .86). Comprehension of a sentence was measured by asking the child to look at three pictures and point to the correct picture. SC1 involved four subtests with a total of 42 items, the meaning of the sentence depended on key words within the sentence. SC2 involved two subtests with 42 items, the order of the words within the sentence determined the meaning of the sentence. The score on the Raven's Coloured Progressive Matrices of the children at the age of four was used as measurement of general intelligence (Raven, 1998). The score on the digit-span task (DS) from the Kaufman test at the age of four was used as measurement of auditory short term memory (Kaufman & Kaufman, 1983).

Procedure

The language tasks were administered to the children at their own schools by their own staff (i.e., psychologists, psychological assistants, and/or speech-language pathologists). Prior to initial assessment, test procedures were explained to the school staff by the researchers. The language data were subjected to a number of analyses to answer the research questions. First, the descriptive statistics (i.e., means and standard deviations) were calculated for each of the two measurement occasions and compared to the normative data with the aid of t-tests. In such a manner, the degree of delay on the language tasks could be determined per measurement occasion and a longitudinal picture across the two measurement occasions was also attained per language task. Second, confirmatory factor analyses were conducted with the aid of the AMOS 5.0 computer program (Amos, 1995). This program uses the technique of structural equation modeling (SEM), which allows the

likelihood of a particular model to be tested. The relations between different factors over time were explored by entering the factors into a model and studying the "goodness of fit" of the model to the data. The fit of the estimated model was assessed by Chi-square (χ^2), with degrees of freedom and probability, the Adjusted Goodness of Fit Index (AGFI), Normed Fit Index (NFI) and the Root Mean Square Error of Approximation (RMSEA). The smaller the χ^2 relative to the degrees of freedom, the better the fit of the model. A model is acceptable if the ratio χ^2 to degrees of freedom is smaller than 2:1, the AGFI and NFI higher than .80 and the RMSEA lower than .06 (Hu & Bentler, 1999). In such a model, a factor from measurement occasion two can be influenced by one or more factors from measurement occasion one. At the same time, the different factors at occasion one can be influenced by cognitive proficiencies of the children.

Results

Descriptive statistics

The means and standard deviations for the language tasks administered on the two occasions and the cognitive measures administered on two occasions are presented in Table 1. For a few tasks, no Dutch norms were available. This holds for the experimental tasks concerned with speech (i.e., the dyspraxia tasks) and phonology (i.e., the experimental Dutch version of the Lindamood Auditory Conceptualization Test). For these tasks, no t-tests could therefore be conducted with the exception of the Dutch version of the LAC for six-year old children. Table 1 shows the children in our sample to attain significantly lower test results than the norm groups on all of the tasks for which t-tests could be conducted. Bonferroni corrections were applied to the t-tests.

Table 1 . Means and standard deviations for research group on two measurement occasions, norms, t-scores, and F-scores.

	Measurement 1 N=97		Norms 5-years olds[1]		t-score MM1[2]	Measurement 2 N=84		Norms 6-years olds[1]		t-score MM2[2]
	M	SD	M	SD	T	M	SD	M	SD	T
LAC[c]	7.98	5.92				13.22	6.66	41.3	18.6	12.69**
PD	35.25	8.28	46,10	5.05	17.17**	41.07	7.50	48.44	2.59	16.84**
WP	8.73	4.85	11.85	6.10	4.75**	12.15	4.66	15.59	5.32	5.58**
RV	43.21	14.19	66.17	13.09	15.59**	60.47	14.57	76.61	10.78	12.01**
PV	22.79	10.37	31.85	8.20	9.51**	31.29	8.69			
WD	7.12	4.85	18.84	6.25	17.47**	11.93	5.78	23.54	6.37	15.66**
SC1[b]	27.59	6.14	33.15	5.13	9.44**	32.93	5.08	36.69	3.60	8.29**
SC2[b]	26.67	6.39	31.42	5.29	7.81**	32.25	5.33	34.39	5.21	3.47**
DYS1[a]	3.46	2.52				4.71	2.34			
DYS3[a]	3.44	2.70				4.93	2.56			
AT	26.87	12.11	43.84	2.00	29.43**	33.02	10.03	44.62	1.03	25.19**

1: N = 500 for the TAK tasks. **: p < .01
2: t-test for independent samples. *: p < .05
a: No norms for the experimental speech production tasks.
b: Subtest data not available for normal population.
c: Only norms for 6-year olds.

All t-scores appeared significant at $p < .01$. This means that the five- and six-year-old children show large and persistent delays on all language tasks as compared with the norm groups. The mean score on the Raven Progressive matrices of the children at age four was 4.7 (SD 1.99). Mean score of the norm-sample is 5.0 (SD 2.0). corresponding with an IQ of 100. There is no significant delay of the children in our sample with respect to general intelligence measured by the Raven. The mean score on the digit span task on age four was 6.03 (SD = 2..42). Norm-mean score is 10.0 (SD = 3.0). There is a significant delay of the children in our sample on this task (T-score = 12.98, $p < .01$).

Language factors

The presupposition that the language skills of children with considerable language problems can be classified into four classic domains, phonology, lexical, syntax and speech, on the two separate occasions was tested in two confirmatory factor analyses (CFA). The goodness of fit measures for the CFA on measurement occasion one were found to be: χ^2_6 = 144.98, p = 0.023, AGFI = .78, NFI = .81 and RMSEA = 0.058 . The goodness of fit measures for the CFA on measurement occasion two were found to be: χ^2_6 = 130.78, p = 0.12, AGFI = .78, NFI = .84 and RMSEA = 0.044.

The results of the CFA's are presented in Table 2. These values of the AMOS-analysis are satisfactory and supported the four factor solution: phonology, lexical-semantic knowledge, syntax and speech production. The strengths of the factor loadings for the different language variables were quite stable over the two measurement occasions, and factor profiles were also quite comparable. The factor phonology consisted of two tasks, the phonological discrimination task and the LAC-test, and was stable over the two measurement occasions. The factor speech production consisted of three tasks for which the correct pronunciation of words was scored. The factor syntax consisted of six subtests involving two different receptive grammatical language tasks. And the factor lexical-semantic knowledge consisted of the receptive and productive vocabulary tasks, the word definition task, and the word production task.

Relations between language factors

In order to examine the relations between the four language factors over time, the predictive associations between the language factors from measurement occasion one to occasion two were examined. The regression weights from the SEM analyses for the factors are presented in Figure 1. The goodness of fit measures for this model were found to be: χ^2_6 = 743.25, p = 0.000, AGFI = .63, NFI = .66 and RMSEA = 0.073. All factors appear to be stable in time. The factor Lexical-semantics had a regression coefficient of .99 from

measurement occasion one to measurement occasion two. The regression coefficients for the factor syntactic proficiency for the first to the second measurement occasion is .92.

For the factor Phonology, the regression coefficient from the first to the second measurement occasion is .68 and for the factor Speech the regression coefficient is .82.

TABLE 2. Results of confirmatory factor analysis for speech and language tests.

TEST	Phonology		Lexical-semantics		Syntax		Speech production	
	mm1	mm2	mm1	mm2	mm1	mm2	mm1	mm2
LAC	.68	.71						
PD	.61	.71						
WD			.59	.65				
PV			.78	.79				
RV			.75	.84				
WP			.72	.61				
SC1a					.79	.72		
SC1b					.66	.78		
SC1c					.49	.53		
SC1d					.72	.59		
SC2a					.77	.86		
SC2b					.82	.85		
DYS1							.86	.87
DYS3							.83	.81
AT							.78	.75

Figure 1 also shows that the language factor syntax highly correlates with the language factors Lexical-semantics (.80) and Phonology (.71). The language factor Lexical-semantics shows medium correlations with the language factors Phonology (.44) and Speech (.31). Other correlations between language factors are low and therefore not shown in the figure.

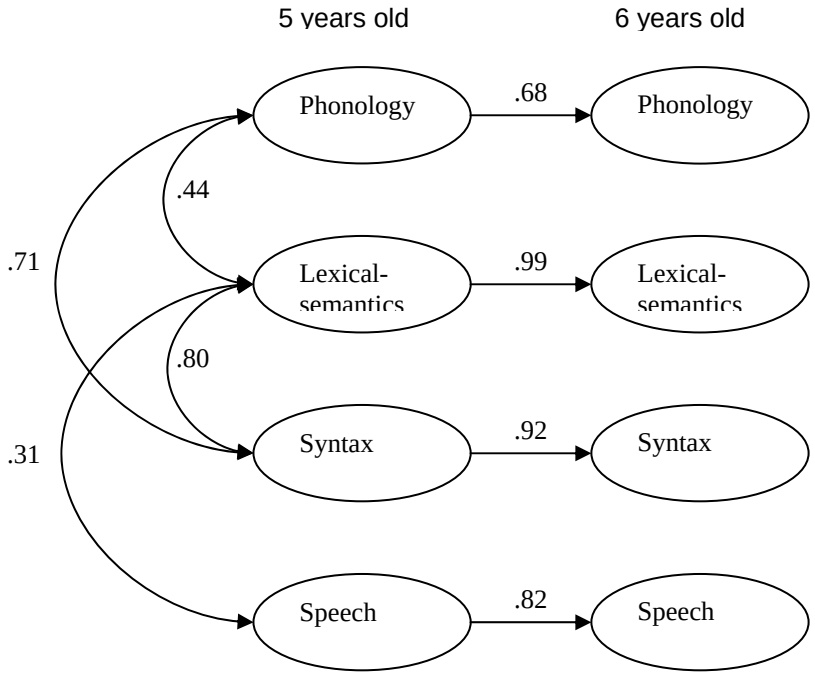

Figure 1. SEM-model language development from the age of 5 to 6 years

The role of cognitive factors

The influence of two aspects of cognition, namely general nonverbal intelligence and auditory short term memory, on the different language factors was explored by incorporating the two variables into the SEM analyses as independent variables and then seeing which significant relations with the language factors were present on measurement occasion one. The goodness of fit for the extended model was then again examined. The obtained model with the associated regression coefficients is presented in Figure 2. The goodness of fit measures for the CFA of this model were found to be: χ^2_6 = 864.40, p = 0.000, AGFI = .62, NFI = .63 and RMSEA = 0.077.

Raven Nonverbal Intelligence shows slight predictive values to the three language factors Phonology, Lexical-semantics and Syntax (to syntax .18 and the to other two .16). Short-term memory as measured with the Digit-span task shows the highest predictive value to the language factor Syntax (.45). This variable furthermore shows moderate predictive values to Phonology (regression coefficient .31), Lexical-semantics knowledge (.27) and Speech (.26).

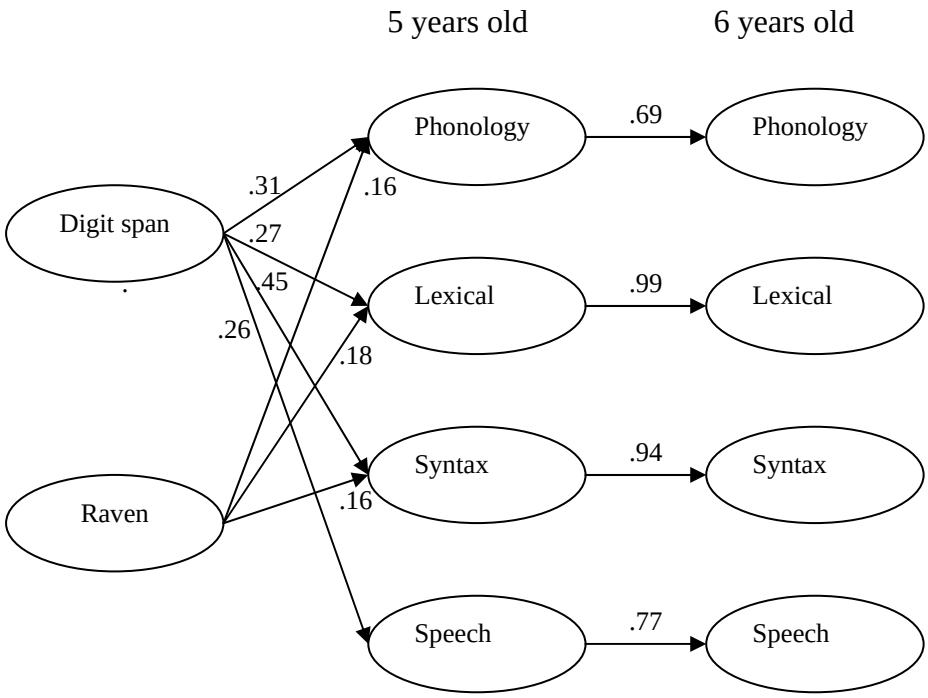

Figure 2. Digit span and Raven as predictors of language development.

Conclusions and discussion

From the present study, several conclusions can be drawn. First of all, our descriptive statistics show the language development of the research group to strongly lag behind the language development of the norm group on two measurement occasions, namely between five and six years of age.

With respect to our second research question, the results of the confirmatory factor analyses with the aid of SEM provided empirical evidence for four distinct language factors on the two measurement occasions. The language factors were: Phonology, Lexical-semantics, Syntax and Speech. The factor Phonology consisted of the composite score from the Lindamood Conceptualization Test (LAC) and the phonological discrimination (PD) test score. Auditory/phonological problems have been cited in classification studies (e.g., Rapin, 1996). Auditory processing problems have been extensively studied among children with language problems and are currently assumed to be one of the causes of the language problems for some – but not all – of these children (e.g., Bishop, Carlyon, Deeks & Bishop, 1999).

The Lexical-semantics factor consists of both receptive and expressive language tasks. The results indeed show the tasks to appeal to the capacity of the child to convey and understand the meaning of words and sentences. That is, semantic information is conveyed in these tasks by words combined with pictures or words embedded in sentences. Given the young age of the research group, one can speak of a severe delay in the building of the children's vocabulary skills. Some of these children appeared to have severe word-finding problems. Lexical-semantic language problems and word-finding problems of the children have been described in various classification studies (Haynes et al., 1991; Rapin ,1996). Problems with word learning and word production may be accompanied by insufficient semantic knowledge and delayed phonological processing with workdproduction problems for newly learned words emerging as a striking limitation on the part of the children in particular (Gray, 2004).

The third factor, Syntax, is only explicitly mentioned in the classification literature in the relatively recent overview presented by Rapin (1996). The grammatical problems of children with language acquisition problems have nevertheless been the topic of previous studies. In fact, van der Lely and colleagues have postulated the existence of a very specific subtype of language acquisition problems in a number of papers, namely "grammatical SLI" (G-SLI) (see, for example, van der Lely & Stollweck, 1997). In more recent research, however, it has been argued that the existence of such a selective language deficit on the part of children is probably rare and that children with grammatical language acquisition problems typically have other language acquisition problems as well (e.g., Thomas & Karmiloff-Smith, 2005). It is also argued that the attained picture often depends on – for

example – the nature and intensity of language remediation received by the research group. It is nevertheless very possible that grammatical language gradually develops and that the most typical grammatical language problems thus appear among only older children. In a recent study, van der Lely speaks of heterogeneity of language acquisition problems with possibly multiple causes and the concomitant question of how problems with respect to the grammar of a language can influence lexical learning (van der Lely, 2005). At the same time, the attention of researchers is shifting from the study of problems with the learning of linguistic rules to the role of processing deficits such as auditory perception problems in the emergence of grammatical language problems on the part of children (Joanisse, 2004).

The fourth factor, speech production, is mentioned in many studies of the classification of language problems (e.g., Rapin, 1996). This literature also shows that the speech problems of children with language acquisition problems may be not only severe but also often occur at a young age (Law, Boyle, Harris, Harkness & Hye, 2000). The loadings of the different articulation tasks on the speech production factor within the present study were all high, which shows the speech problems represented by this factor are diverse and can be associated with phonological problems, motor problems and planning problems such as dysfluency.

It is interesting to note that the results of the confirmatory factor analysis revealed the same four language factors on both measurement occasions. All language factors turn out to be stable in time. Furthermore, factors are found to be related to each other: Phonology relates with Lexical-semantics and Syntax whereas Lexical-semantics is related with Syntax and Speech. This result is fully commensurate with current neurobiological models of language processing in normal and deviant populations showing that grammatical and lexical structures differ and seem to involve different but also interdependent brain systems (e.g., Hagoort, 2005). For children with SLI, this seems to imply that serious grammatical impairment goes along with serious impairments in lexical-semantic development, and visa versa (e.g., Leonard & Deevy, 2003). Recent studies indeed show that the development of lexical-semantics and syntax develop more or less synchronously (e.g., Dixon & Marchman, 2007). The relationships we found between Phonology, on the one hand, and Syntax and Lexical-semantics, on the other hand, are in line with other studies that have shown that perceptual processing deficits that affects the use of phonological information can give rise to both grammatical and lexical deficits in children with SLI (e.g., Tallal, 2000). The language data from our study also seem to indicate that speech production in children with SLI is relatively less related to the other domains of their language development. This result conforms to findings from previous studies showing that speech problems can be highly specific due to neuromuscular problems or anatomic abnormalities, and may occur independently of other language problems (e.g., Groenen, Maassen, Crul & Thoonen, 1996).

Our third research question concerns the possible role of cognitive factors in the language development of the children studied here. The nonverbal IQ of the children in our study showed low regression coefficients with the three language factors and no regression with speech. Moreover, nonverbal IQ was no predictor of only one specific aspect of their language one year later which is in line with other recent studies looking at for instance grammatical proficiency and nonverbal IQ (Rice, Tomblin, Hoffman, Richman and Marquis, 2004). With respect to the predictor measure of short-term memory, we found a strong prediction of Syntax and moderate predictions of the other three language factors at age five. This is in line with previous studies (cf. Gillam, 1997). It is also commensurate with evidence from neurobiological studies showing that SLI can at least partly be explained by deficits in brain structures that are responsible for procedural memory functions (Ullman & Pierpont, 2005). The digit span task involves phonological as well as sequential processing procedures that are key-proficiencies in language acquisition. Thinking in a bottom-up way, auditory and phonological processing constraints lead to a delay in language acquisition. Due to these procedural processing problems, some children with SLI seem to make less use of syntactic knowledge in language understanding. And thinking in a top-down way, these language understanding problems could be counterproductive of bootstrapping: instead of language and procedural processes supporting each other, those processes could get more and more isolated resulting in severe and persistent SLI (e.g., Leonard, Weismer, Miller, Francis, Tomblin & Kail, 2007). This view of longitudinal relations between language acquisition and developing processing skills clearly will need much more and intensive research using extensive language and processing data of children with SLI. Since, as Ullman & Pierpont (2005) as well as Hagoort (2005) point out, brain structures are involved in a connectionistic way, neuro-imaging should take place as well in such studies.

Some limitations on the present study

In the present study, children studied all visited a special school for children with SLI. The results of the present study can thus be seen as reliable with respect to the language factors that are made by this particular population. The attained picture may nevertheless be very different for other age groups and/or children with less SLI although the results of the recent study by van Weerdenburg (2006) provide clear indications that comparable language factors can be distinguished for children with SLI between the ages of six and ten years.

It should also be noted that we distinguished classic linguistic domains of lexicon, syntax, phonology, and speech for the composition of the test battery as both reliable and valid measurement instruments were available for these domains of language in the Netherlands. As revealed by the factor analyses, however, certain domains of language were not included in the current picture as a result. This holds for the “expressive syntactic

language proficiency" of the children. In order to study this capacity, utterances must be elicited or spontaneous speech samples must be gathered, but such data collection and analyses were beyond the scope of this study. The current literature also suggests that it may be reasonable to assume that such a factor as "pragmatic language capacity" can be distinguished. These types of language problems are generally assessed using observations and checklists such as the Children's Communication Checklist (Bishop, 2003), which is a different kind of data gathering than psychometric testing of children and can not be easily taken as an extra variable in factor analysis. In the present study, it was attempted to incorporate the relations between different aspects of cognition and various language factors into an interactive model of children's language learning. Finally, the research group studied here did not differ greatly with regard to the severity of their language problems but possibly with regard to such aspects as early detection, prior speech-language therapy, and/or level of communication training of the parents. One or more of these aspects of the language environment may have played a particularly facilitating role for some of the children in the research group and thereby allowed their language development to progress more quickly than the language development of the others in the research group. Data on larger groups of children should therefore be gathered in future studies in order to form subgroups of children using the aforementioned variables and possibly to distinguish different developmental profiles.

Practical implications

Given the role of auditory memory problems in the language problems of children, it is imperative that the short-term memory capacities of children with language problems always be examined. And specific interventions and the training of the auditory memory capacity should be undertaken when memory problems are detected. More extensive neuropsychological examination should take place as soon as possible in children with more severe and extensive language acquisition problems in order to look at the kind of procedural processing problems. Results of such examinations should lead to specific training programs in which language and processing demands are measured against the individual proficiencies. Possibly different aspects of information processing play a different role at different stages of language development. The treatment of children with major delays in one or more domains of language should therefore not be aimed, in our view, at only the domain with the largest delay but also at the stimulation of development in related domains. This may include not only other language domains but also neurocognitive and – for example – motor domains. The development of these related domains can presumably speed the language learning process. A cognitive shift related to more conscious awareness of language processing and the ability to reflect upon linguistic input possibly occurs around the age of

five in children with SLI. The children seemed also to become more aware of their language learning and language comprehension at this age. It is thus important that therapists and teachers also become more aware of this shift in the language thinking of young children as such a shift can have important implications for the manner in which language remediation efforts are pursued (e.g., Tyler, Lewis, Haskill & Tolbert, 2003). For children up until about the age of five years, remediation efforts should be mostly indirect and thus occur largely via the language environment. For children over the age of about five years, direct remediation can frequently be undertaken in light of the reliance of such methods on the conceptual and reflective capacities of the children. In light of the present results, however, this may hold to a much lesser extent for the remediation of specific speech problems.

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Chapter 4

Working memory limitations in children with severe language impairment [1]

Abstract

In the present study, the relations of various aspects of working memory to various aspects of language problems in a clinical sample of 97 Dutch speaking 5-year-old children with severe language problems were studied. The working memory and language abilities of the children were examined using an extensive battery of tests. Working memory was operationalized according to the model of Baddeley. Confirmative factor analyses revealed three memory factors: phonological, visual and central executive. Language was construed as a multifactorial construct, and confirmative factor analyses revealed four factors: lexical-semantic abilities, phonological abilities, syntactic abilities and speech production abilities. Moderate to high correlations were found between the memory and language factors. Structural equation modelling was used to further explore the relations between the different factors. Phonological memory was found to predict phonological abilities; central-executive memory predicted lexical-semantic abilities; and visual memory predicted speech production abilities. Phonological abilities also predicted syntactic abilities. Both the theoretical and clinical implications of the findings are discussed.

Learning outcomes: The reader will be introduced to the concepts of multifactorial components of working memory as well as language impairment. Secondly the reader will recognize that working memory and language impairment factors can be related. Particular emphasis will be placed on phonological memory, central-executive memory and visual memory and their possible prediction of specific components of language impairment.

Introduction

Information-processing theories occupy an important position in the study of children's language development and language impairment. Research has clearly shown information-processing factors to constrain children's language processing (see Gathercole & Baddeley, 1990a, 1990b; Fazio, 1996; Gillam, 1997; Martin & Saffran, 1997). In addition to attention and concentration, the working of memory is one of the aspects of information processing studied most frequently in conjunction with children's language development (cf. Baddeley, 2003).

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Correlations between working memory or what is also called short-term memory and the normal language development of children have been demonstrated in numerous studies (Adams & Gathercole, 1996, 2000; Ardila & Rosselli, 1994; Gathercole, Willis, Baddeley, & Emslie, 1994). A relation between working memory and language development has also been demonstrated in numerous studies for children with specific language impairment (SLI). (Adams & Gathercole, 2000; Balthazar, 2003; Ellis-Weismer & Evans, 2002; Ellis-Weismer, Evans & Hesketh, 1999; Friel-Patti, 1999; Gathercole, Tiffany, Briscoe, & Thorn, 2005; Gillam, Cowan, & Day, 1995; Gillam, Cowan, & Marler, 1998; Kircher & Klatzky, 1985; Marton & Schwartz, 2003; Montgomery, 2000a, 2000b, 2002, 2003, 2004; Pickering & Gathercole, 2004).

In the studies of the relations between working memory and language development reported in the literature, the model of Baddeley is often used to describe the operation of working memory (Baddeley, 2002, 2003; Baddeley & Hitch, 1974; Baddeley, Gathercole, & Papagno, 1998; Burgess & Hitch, 1992; Hoffman & Gillam, 2004; Just & Carpenter, 1992; Martin & Saffran, 1997; Martin, Lesch, & Bartha, 1999). The model involves two basic aspects where phonological and visual information are briefly and statically retained, namely the phonological loop and the visual sketchpad. The processing of phonological information is thought to have an inner rehearsal aspect (the articulatory loop) which allows the phonological information needed for the process of language comprehension to be retained longer in memory. A third more central aspect of Baddeley's model is the central-executive system which constitutes the control mechanism to coordinate the storage and processing of basic information.

Numerous studies have examined the relations between phonological working memory and problematic language development. In doing this, phonological working memory has been tested in different manners. In some studies, children have been asked to repeat a number of words (e.g., Balthazar, 2003; Montgomery, 2000a, 2000b; Nation , Adams, Bowyer-Crane, & Snowling, 1999; Rosenquist, Conners, & Roskos-Ewoldson, 2003). In other studies, children have been asked to either repeat nonsense words (Adams & Gathercole, 1996; Bishop, North, & Donlan, 1996; Ellis-Weismer, et al., 2000; Gathercole, et al., 1994; Marton & Schwartz, 2003; Montgomery, 2003; Norrelgen, Lacerda, & Forssberg, 2002). And in still other studies, children have been asked to repeat sentences, parts of sentences or lists of numbers and words presented aurally, sometimes presented at different speaking rates or with different serial positions (e.g., Adams & Gathercole, 1996; Allen, Lincoln, & Kaufman, 1991; Ardila & Rosselli, 1994; Bain, 1993; Fazio, 1996; Gillam, et al., 1995; Isaki & Plante, 1997; Mainela-Arnold & Evans, 2005; Martin & Saffran, 1997; Marton & Schwartz, 2003; Montgomery, 2000a, 2000b, 2004).

The relations between the visual aspect of working memory and language development factors have also been studied (Hale, Meyerson, Rhee, Weiss, & Abrams, 1996; Hale, Bronik, & Fry, 1997). Such studies are based on the assumption of multiple representations and the assumption that children under the age of 10 years can still suffer non-specific interference with the language learning process (i.e., interference from a spatial task during the performance of a verbal task). Verbal working memory has also been found to develop faster than visual working memory. Within the context of the dual coding theory of Paivio (Clark & Paivio, 1991; Paivio, 1986), the simultaneous processing of verbal and nonverbal information by young children has been considered in depth. Dual Coding Theory proposes that memory consists of two separate but interrelated codes for processing information—one verbal and the other visual. The verbal and visual systems can be activated independently, but there are interconnections between the two systems that allow dual coding of information. The image which emerges with regard to the weak visual working memory of particularly children with language impairment is less clear. Both Tomkins (2000) and Hoffman and Gillam (2004) showed children with SLI to have problems with the visual sketchpad. However, Adams and Gathercole (2000) found an inconsistent pattern of relations between performance on two visual-spatial short term memory tasks and language performance. Due in part to the differences in the visual memory tasks, additional research is therefore recommended.

With respect to the relation between the central-executive memory functioning of children and their language development, it has been shown that problems switching between different aspects of information-processing can correlate with language development problems (Baddeley & Della Sala, 1998; Baddeley, Emslie, Kolondy, & Duncan, 1998). Research on the central-executive problems of children with specific language impairment is quite scarce, but recent studies have shown the efficiency of children's executive memory functions to constrain their language development (Hoffman & Gillam, 2004; Numminen, Service, Ahonen, & Ruoppila, 2001; Marton & Schwartz, 2003).

The preceding review shows considerable evidence for the influence of phonological information processing (i.e., phonological working memory) on the language development of children with SLI. Unfortunately, very little research has been undertaken with respect to the possible influences of the other aspects of working memory on the language development of children with SLI. And one problem with the few earlier studies of the relations between working memory and specific language impairment is further that language mastery is often approached as a monolithic entity. Recent studies have nevertheless shown the language learning problems of children with SLI to be multifactorial (Conti-Ramsden, Crutchley, & Botting, 1997; Conti-Ramsden & Botting, 1999; van Daal, Verhoeven, & van Balkom, 2004). And these findings are in keeping with the findings of earlier classification studies of severe

language problems (Aram & Nation, 1975; Aram, Ekelman & Nation, 1984; Fletcher, 1991, 1992; Haynes & Naidoo, 1991; Rapin, 1996; Rapin, Allen, & Dunn, 1983; Wilson & Risucci, 1986; Wolfus, Moscovitch, & Kinsbourne,1980).

The aim of the present study was therefore to draw upon the model of Baddeley and examine different aspects of working memory in relation to the different language abilities of 5-year-old children with severe language impairment in the Netherlands. The language impairments of the research group are so severe that special education is necessary. In the Netherlands, the language development of children is meticulously followed via both health centres and the education system. Problems with speech and language development are commonly discovered around the age of 3 years after which specific help and speech therapy can be launched. When the problem proves persistent and the following of the educational curriculum is severely impeded, the child can be placed in one of about 30 schools specifically designed for children with severe and persistent speech and language problems in the Netherlands. In the present study, an attempt was thus made to answer the following questions: (a) How do children with severe language impairment score on various memory and language tests when compared to peers with normal language development? The expectation is that the children with severe language impairment will consistently score lower on all of the memory and language tests. (b) What factors underlie the working memory and language abilities of the children with severe language impairment? With respect to working memory, the phonological, visual and central-executive factors from the model of Baddeley are expected to characterize the children with severe language impairment as well. With respect to language abilities, the results of previous research among 4-year-old children with severe language impairment (van Daal et al., 2004) suggest that speech production, phonological, syntactic and lexical-semantic knowledge factors will also underlie the language abilities of the children with severe language impairment studied here. (c) How do the various working memory and language factors relate for the children with severe language impairment?

Method

Subjects

The subjects were recruited from special schools for children with severe language impairments in the Netherlands. Children are referred to such a special school after extensive clinical and psychometric examination by an educational psychologist and a speech-language pathologist. Admission must also be approved by an independent board which checks the indication for admission. This board checks the severity of the language impairment by looking at a child's scores on language tests. For admission to a special school for children with language impairments a child has to have one test score at least two

standard deviations below the mean or two language test scores 1.5 standard deviations below the mean.

The children that participated in this study had, conform the Stark & Tallal exclusion-criteria (1981), nonverbal intelligence scores within the normal range (NV-IQ > 70), no sensorimotor deficits and no psychiatric disorders. Children with any apparent hearing problems (i.e., a loss of 30 dB or more in the best ear) were excluded from the study. Non-native speakers of Dutch were also excluded.

Out of 29 such schools, 23 agreed to participate.. The parents of the children provided permission for their participation. At the time of test administration, the mean test-age for the cohort was 64 months. A total of ninety-seven 5-year-old children (i.e., 72 boys and 25 girls) were randomly selected with a greater number of children coming from relatively larger schools.

Procedures and measures

The children were tested at school by their speech-language pathologists or psychological assistants. The test procedures were explained by the research staff. For the nonstandardized tests (DYS1 to DYS5), all test assistants were trained administering and interpreting the tests until they yielded high inter-examiner reliability standards (i.e., agreement with standards greater than 95 percent).

Six measures of working memory were administered. These measures were selected from existing psychological tests because speech-language pathologist or psychologists are familiar with these measures. The measures selected are therefore different from current experimental measures of working memory. The phonological working memory was examined using two tests: the digit span test (i.e., listening to and repeating increasingly long lists of numbers in the correct order) and the word order test (i.e., remembering a sequence of words and pointing in the correct order to the associated illustrations shown after 5 seconds). The two tests are part of an existing psychological test, namely the Kaufman Asessement Battery for Children (K-ABC, Kaufman & Kaufman, 1991). Visual-spatial memory was examined using two tests in which lists of pictures must first be memorized and then placed in exactly the same order 5 seconds later. Once again, a clearly sequential aspect is present and both tests are part of an existing test — in this case, the Dutch intelligence test RAKIT (Bleichrodt, Drenth, Zaal, & Resing, 1984). Finally, central-executive working memory was examined using a test in which illustrations of cats and butterflies are given a name in conjunction with a semantic cue (see figure 1 for example test item). This semantic cue can be hidden in the name itself, in some details of the picture or can be provided in a supplemental sentence. Complex visual and verbal information have thus to be simultaneously processed in this test and therefore we think this task is an example of a dual

(verbal and visual) and complex memory task although not competing (Ellis-Weismer, et al., 1999). This tasks resembles the dual processing task DPCT (Ellis-Weismer, 1996; Gutiérrez-Clellen, Calderón,& Ellis-Weismer, 2004) but in our task there is an verbal and visual linguistic modality. After the memorization of 12 names, the illustrations are again shown and the child is asked to recall the relevant names (test one). The illustrations are later shown a second time (test two). This test also comes from the Dutch intelligence test RAKIT.

'This is Snow White''. That is her name because she's all white'.

Fig 1. Test-item of Name=learning task

The language tests were selected to measure speech production, phonology, lexical-semantic knowledge and syntactic language proficiency. Some of the tests measured only one aspect of language proficiency while others measured more than one aspect. Some of the language tests were also audiotaped in order to check the reliability of the scoring. And all of the tests involved standardized procedures and have been shown to have sufficient content validity.

The speech production abilities of the children were tested using the articulation test from the Dutch test for language proficiency — the Taaltoets Alle Kinderen (TAK, Verhoeven & Vermeer, 2001) — and the 5 Speech Dyspraxia tests (i.e., DYS1 - DYS5) which constitute the Dutch battery used to test for 'developmental apraxia of speech' (DAS, Maassen, 1999).

All of the other language tests from the TAK (Verhoeven & Vermeer, 2001) were similarly administered to measure the other aspects of the children's language proficiency.

The phonological abilities of the children were measured using two tests. The first was the sound discrimination test from the TAK. The second was the Dutch experimental version of the Lindamood Conceptualization test (LAC) (Lindamood & Lindamood, 1971; Simkens, 1999).

An overview of the various memory and language tests included in the speech, language and memory test battery is presented in Table 1. The test procedures are also briefly described. Reliability of the tests used accounted for using the internal consistencies of the different tests. These were measured by Cronbach's alphas. Table 1 shows that almost all reliability estimates are moderate (around .80) to high (around .90).

TABLE 1. Overview of the test battery.

Type of tests	Abbreviation	Label of the test	Brief description of the test
Memory tests	WR	Word Recall Kaufman-ABC (Guilford = .85)	Memory and recall of sequences of words. After hearing a sequence of words the child has to point to corresponding pictures in the correct order. The number of words to be recalled increases. Testing is stopped after 3 consecutive errors or at ceiling.
	DS	Digit Span Kaufman-ABC (Guilford = .83)	Repetition of sequences of digits heard. The number of digits to be recalled increases. Testing is stopped after 3 consecutive errors or at ceiling.
	NA1	Name learning RAKIT	10 Pictures of cats and butterflies are matched with names. Sometimes a semantic cue is given in the name itself or in a short sentence in which the name is presented. After teaching the 10 names, the child is asked to name the pictures. After each item, feedback is given.
	NA2		After the first trial of naming and feedback, the child is again asked to name the pictures.
	SYM1	Symbolic memory RAKIT	Pictures of concrete objects are shown for 5 seconds; the child then has to reproduce the correct picture order. Total number of 18 items; number of the pictures to be remembered increases.
	SYM2		Same procedure as Sym1 but abstract figures are now used. Again the total number of items is 18.
Speech production tests	AT	Articulation test TAK* (α = .91)	Repetition of 45 short words covering all of the possible speech sounds in Dutch. Children have to complete all the items and reproduce them phonologically correctly. The scoring procedure concerns all the speech tests in the test battery.
	DYS1	Picture naming* (α = .86)	Naming 8 pictures of normal objects (e.g., an airplane or a TV). Children have to name the object spontaneously. If they do not do this, naming is elicited using an incomplete sentence.
	DYS2	Diadochokinetic movements 1*(α = .76)	Repetition of 12 syllable stings, each containing 2 to 4 consonant-vowel-(vowel) syllables.
	DYS3	Word repetition 1* (α = .62)	Repetition of 10 words covering all of the vowels in the Dutch language.
	DYS4	Diadochokinetic movements 2* (α = .82)	Repetition of 11 syllable stings, each word contains 3 consonant-vowel syllables using only the vowel /a/ (e.g., 'sa-pa-da') .
	DYS5	Word repetition 2* (α = .89)	Repetition of contrasting word-pairs matching pictures (15 items). The word pairs have a CVC-structure; pairs differ with respect to one of the consonants.
Syntactic language tests	SC1 & SC2	Sentence comprehension tests TAK 1 (α = .82) and test 2 (α = .86)	Comprehension of a sentence is measured by asking the child to look at three pictures and point to the correct picture (42 items, all administered). In SC1 the meaning of the sentence depends on key words in the sentence; in SC2, the order of the words in the sentence defines meaning.
Lexical-semantic knowledge tests	SR	Sentence repetition test TAK* (α = .95)	Repetition of elements of 20 long sentences. Correct repetition of function words and core sentence patterns is scored. Administration is stopped after 5 consecutive failures.
	WP	Word production test TAK (α = .83)	The child views a picture and hears an incomplete sentence in order to elicit word endings (24 items).
	NT	Narrative tests TAK* (α = .90)	The child is presented a comic strip (8 pictures) and is asked to tell a story. The test contains two stories. Content (i.e., meanings and relations) is scored (as opposed to syntactic structures of the sentences).
	RV	Receptive Vocabulary test TAK (α = ..95)	The child is asked to point to one of four pictures after hearing a word (96 items; testing is stopped after 5 consecutive errors). Administration is stopped after 5 consecutive failures.
	PV	Productive Vocabulary test TAK (α = .90)	Naming of pictures (60). Testing is stopped after 5 consecutive errors.
	WD	Word Definition test TAK* (α = .88)	A pure verbal test, the child has to define words. Testing is stopped after 5 consecutive errors.
	SCT	Story Comprehension test TAK (α = .88)	Six stories are read aloud. After each story, four questions about the content of the story must be answered by the child.
Phonological language tests	LAC	Dutch experimental version of the Lindamood Auditory Conceptualization test	The child must reproduce sequences of phonemes by matching a specific colour block with a phoneme and placing blocks in the correct order (maximum score is 28; part 1 has 16 items and all items are administered; part 2 has 12 items and testing is stopped after 5 consecutive errors).
	PD	Phonological discrimination test TAK (α = .96)	The child has to listen to pairs of words and tell if they are the same or not (50 pairs: 37 different and 13 identical), all items are administered. The word pairs differ with respect to one phoneme.

*** = test was audiorecorded. α = Cronbach's reliability-coefficient.**

Data analysis

About 1.5% of the missing values were encountered and subsequently estimated using the nearest neighbour method. In the relevant data matrix, children with score profiles which resemble the profile of the child for which a missing value has been detected are sought. On the basis of the scores of the other children on that particular subtest, the missing value is then estimated. In order to find an answer to the first research question, the descriptive statistics for the various memory and language tests were calculated. T-tests were conducted to determine the significance of the differences between the data for the children with SLI and the normative data provided for the different tests.

Confirmative factor analyses were conducted to answer the second research question. The correlation coefficients between the memory and language factors and also the language factors themselves were examined using the categories of medium (.30) and large (.50), as Cohen (1988) suggests.

In order to answer the third research question, the proposed relations between the different aspects of working memory and the various language factors were examined. Structural equation modelling technique (SEM) was used. The model is based on theoretical hypotheses, the constructs of interest are operationalized and the model is tested using statistical software, AMOS 5.0. Analysis are run using the covariance matrices. The Goodness of fit of the estimated model was assessed by Chi-square (χ^2), with degrees of freedom and probability, the Adjusted Goodness of Fit Index (AGFI), Normed Fit Index (NFI) and the Root Mean Square Error of Approximation (RMSEA). The smaller the χ^2 relative to the degrees of freedom, the better the fit of the model. A model is acceptable if the ratio χ^2 to degrees of freedom is smaller than 2:1, the AGFI and NFI higher than .80 and the RMSEA lower than .06 (Hu & Bentler, 1999).

Results

Descriptive statistics

The first research question concerns the extent to which the children with SLI score lower than their peers with normally developing language on the various memory and language tests. The results for the children with SLI were thus compared to the normative data provided in the test manuals for Dutch children. t-Tests for means from independent samples were performed. In Table 2, the means and standard deviations are presented for the SLI and normative samples. In the last column, the results of the t-tests are presented. As can be seen, significant differences were found for three of the four memory tests after combination of the SYM1 and SYM2, on the one hand, and the combination of the NA1 and NA2, on the other hand. In addition, significant differences were found between the groups for all of the language tests.

TABLE 2. Mean scores for sample and normative sample.

	Number of items	Study sample		Normative sample		
		M	SD	M	SD	T-test
Memory						
SUM SYM 1+SYM2	36	14.05	5.60	15.00	5.00	-1.80 $^{p<.10}$
SUM NA1 + NA2	24	13.44	5.65	15.00	5.00	-2.95**
DS	11	5.90	2.79	10.00	3.00	-13.28**
WR		6.93	2.51	10.00	3.00	-9.97**
Language[a]						
RV	96	43.21	14.19	66.17	13.09	-15.59**
PD	50	35.25	8.28	46.10	5.05	-17.17**
AT	45	26.87	12.11	43.84	2.00	-29.43**
WD	45	7.12	4.85	18.84	6.25	-17.47**
SR	20	9.00	8.20	29.40	8.23	-22.35**
NT	16	10.29	6.59	18.23	6.46	-11.04**
SUM SC1a thru SC1d[b]	42	27.59	6.14	33.15	5.13	-9.44**
SUM SC2a and SC2b[b]	42	26.67	6.39	31.42	5.29	-7.81**
WP	24	8.73	4.85	11.85	6.10	-4.75**
SCT	24	12.35	5.69	17.91	4.38	-10.86**
PV	60	22.79	10.37	31.85	8.20	-9.51**
LAC 1a	10	5.19	3.58	9.00	1.70	-16.20**
LAC 1b	6	1.60	1.80	4.00	2.00	-10.99**
LAC 2	12	1.20	1.32	2.10	2.60	-3.33**

Note. N = 97 for sample studied; N = 500 for normative TAK samples; N = 1415 for SYM & NA tests; N= 3098 for DS and WR. Memory tasks mean standard scores, other tasks raw scores.
[a] no norm scores for speech tests DYS 1 to DYS5 available.
[b] Subtest data not available for normal population.
** p < .01.

Underlying memory factors

In Table 3, the intercorrelations between the different working memory tests are presented. The correlation between the two name learning tests (NA1 and NA2) was large. Similarly, the correlation between the phonological tests was large. The correlation between the two visual memory tests was significant but surprisingly low (.39), which suggests that having to remember and recall concrete versus abstract figures makes a considerable difference for children with severe language problems.

TABLE 3. Correlations between scores for different memory tests.

	Na 1	Na 2	DS	WR	Sym 1	Sym 2
Na 1	1.00					
Na 2	.79**	1.00				
DS	.43**	.38**	1.00			
WR	.38**	.41**	.69**	1.00		
Sym 1	.22*	.28**	.30**	.34**	1.00	
Sym 2	.34**	.25*	.20	.28**	.39**	1.00

Pearson correlation coefficients, * = p < .05 and ** = p < .01.

The extent to which the three aspects of working memory included in the model of Baddeley could be distinguished for the children with SLI was next examined. The results of the confirmatory factor analysis conducted for this purpose show the three-factor solution to provide the best fit for the working memory data from the children with SLI. (see Table 4). The goodness-of-fit measures for this model are: χ^2_6 = 10.360, p = 0.011, AGFI = .89, NFI = .95 and RMSEA = 0.087. The first memory factor encompasses the two tests involving the memorization of new names. In light of the nature of the memory abilities required, this factor resembles the *central-executive memory* factor from the model of Baddeley. The second memory factor encompasses two *phonological memory* tests and can therefore be taken to represent the phonological loop from the model of Baddeley. Finally, the third factor encompasses the two *visual memory* tests and can therefore be construed as an exemplar of the visual sketchpad from the model of Baddeley. The central-executive factor showed a correlation of 0.54 with the phonological factor and 0.49 with the visual factor.

TABLE 4. Results of confirmative factor analysis for working memory tests.

	Phonological	Visual	Central-executive
DS	.81		
WR	.85		
SYM1		.65	
SYM2		.60	
Na I			.90
Na II			.88

χ^2_6 = 10.360, p = 0.011 and RMSEA = 0.087

It should be noted that the possible intercorrelations between the different variables are not controlled for in the factor analyses. Given that both the phonological and visual working memory tests have a sequential element, whether a factor solution with a single auditory/visual-sequential working memory factor provides a better fit or not should be considered. This was done by setting the correlation between the auditory factor and the visual factor artificially to 1. The difference between this model and the three-factor model proved significant (χ^2 = 8.881, df = 1). This means that the hypothesis that a two-factor solution containing a single sequential working memory factor can be rejected.

Underlying language factors

In Table 5, the intercorrelations between the various language tests are presented.

The speech production tests can all be seen to demonstrate large intercorrelations with each other. Only one test (DYS5) showed two medium intercorrelations.

TABLE 5. Correlations between scores for different language tests.

	Speech production						Syntax						lexical-semantic knowledge							Phonology	
	AT	DY1	DY2	DY3	DY4	DY5	SC1a	SC1b	SC1c	SC1d	SC2a	SC2b	SR	WP	NT	RV	PV	WD	SCT	PD	LAC
AT	1.00																				
DYS1	.65**	1.00																			
DYS2	.61**	.64**	1.00																		
DYS3	.68**	.70**	.73**	1.00																	
DYS4	.59**	.54**	.66**	.72**	1.00																
DYS5	.53**	.51**	.56**	.47**	.44**	1.00															
SC1a	.14	.26*	.26*	.27*	.29	.49**	1.00														
SC1b	.04	.15	.15	.15	.04	.29**	.57**	1.00													
SC1c	.23*	.28**	.35**	.30**	.25*	.18	.27**	.32**	1.00												
SC1d	.10	.13	.24*	.25*	.29**	.28**	.55**	.38**	.32**	1.00											
SC2a	.02	.19	.18	.16	.21*	.33**	.58**	.45**	.25*	.59**	1.00										
SC2b	.15	.22*	.22*.	.27*	.19	.37**	.60**	.50**	.33*	.60**	.64**	1.00									
SR	.33**	.35**	.45**	.35**	.33**	.47**	.47**	.29**	.43**	.37**	.43**	.43**	1.00								
WP	.32**	.35**	.39**	.31**	.31**	.43**	.35**	.35**	.44**	.40**	.41**	.34**	.52**	1.00							
NT	.47**	.41**	.38**	.40**	.31**	.53**	.38**	.34**	.24*	.27**	.27*	.40**	.45**	.38**	1.00						
RV	.33**	.27**	.36**	.31**	.36**	.43**	.62**	.43**	.40**	.42**	.50**	.51**	.53**	.49**	.53**	1.00					
PV	.31**	.27**	.31**	.28**	.39**	.42*	.38**	.31**	.36**	.43**	.50**	.43**	.47**	.62**	.51**	.64**	1.00				
WD	.18	.15	.24*	.15	.21*	.27**	.41**	.30**	.32**	.42**	.34**	.37**	.58**	.42**	.44**	.52**	.51**	1.00			
SCT	.24*	.15	.26**	.28**	.29**	.38**	.59**	.51**	.47**	.52**	.62**	.58**	.56**	.54**	.48**	.65**	.66**	.60**	1.00		
PD	.06	.15	.30**	.10	.14	.29**	.48**	.32**	.23*	.36**	.45**	.40**	.46**	.37**	.23*	.33**	.29**	.39**	.56**	1.00	
LAC	.05	.19	.26*	.14	.19	.38**	.59**	.42**	.27**	.34**	.37**	.41**	.37**	.35**	.24*	.45**	.24*	.30**	.37**	.44**	1.00

Pearson correlation coefficients, * = $p < .05$ and ** = $p < .01$

The speech production tests also showed at least medium correlations with the Sentence Reproduction test (SR), the Word Production test (WP), the Narrative Test (NT) and the Receptive and Productive Vocabulary tests (RV, PV).

With respect to the two phonological tests (LAC, PD), medium correlations generally occurred with the Sentence Comprehension tests (SC1a-d, SC2a-b), the Word Definition test (WD) and the Story Comprehension test (SCT).

The six Sentence Comprehension tests (SC1a-d, SC2a-b) - which examine the comprehension of syntactic elements - showed medium correlations with the remaining language tests. The correlation with the Story Comprehension Test (SCT) was highest.

In order to answer the second research question, confirmatory factor analyses were undertaken. The results are presented in Table 6.

TABLE 6. Results of confirmative factor analysis for speech and language tests.

TEST	Speech production	Syntax	lexical-semantic knowledge	Phonology
DYS1	.81			
DYS3	.85			
AT	.80			
SC1a		.80		
SC1b		.66		
SC1c		.45		
SC1d		.72		
SC2a		.78		
SC2b		.80		
WD			.63	
PV			.80	
RV			.79	
WP			.71	
LAC				.69
PD				.65

χ^2_{84} = 102.449, p = 0.084 with RMSEA = 0.048.

The question was whether the four-factor structure for language ability demonstrated in previous research with a comparable research population using the same research instrumentation could be confirmed or not (van Daal et al., 2004). Confirmation was indeed found for the four factors: speech production, syntax, lexical-semantic knowledge and phonology.

The goodness-of-fit measures for the four-factor model are: χ^2_{84} = 102.449, p = 0.084 AGFI = .83, NFI = .86 and RMSEA = 0.048. The tests loading on the first factor ask the child to either understand or express different meanings. On three of the relevant tests, the semantic information is conveyed via words (i.e., vocabulary); on the other test, the meaning is conveyed via an entire sentence. The lexical-semantic knowledge factor correlated quite high with both the syntactic factor (0.79) and the phonological factor (0.67) while the correlation with the speech production factor was somewhat lower (0.45). The syntactic factor also correlated high with the phonological factors (0.88) but low with the speech production factor (0.26). Finally, the speech production and phonological factors intercorrelated to a limited extent (0.21).

Relations between memory and language factors

The third research question concerned the relations between the various aspects of working memory and the different language factors for the children with SLI. In addition, the interrelations between the different language factors themselves for children with language development problems were of interest.

The correlations between the different memory and language factors are presented in Table 7. Central-executive working memory showed large correlations with three of the four language factors with the correlation with the lexical-semantic knowledge factor being highest. Visual working memory also showed large correlations with three of the four language factors with the correlation with phonology proving highest.

TABLE 7. Correlations between memory and language factors.

	Speech production	Syntax	lexical-semantic knowledge	Phonology
Phonological	.56	.52	.49	.65
Visual	.32	.54	.51	.64
Central-executive	.32	.52	.70	.48

χ^2_{84} = 220.87 p = 0.04 with RMSEA = 0.057.

Confirmative multiple regression analyses were next conducted. The relations of working memory to the different language abilities of the children with SLI were first examined. Thereafter, which interconnections between the different language factors could be incorporated into the SEM-model on sound theoretical grounds was examined. The three aspects of working memory and four aspects of language abilities were the building blocks for construction of the initial model. In the formulation of the model, the presuppositions mentioned in connection with the research questions were transformed into expected relations. The expected relation was then tested and retained in the model when sufficient statistical evidence for the relation was found. In such a manner, thus, a model is built with

as many theoretically justified relations as possible. To start with, significant relations between phonological working memory and the language factors phonology and syntax were expected. Second, significant relations between central-executive working memory and the lexical-semantic knowledge factor and - due to the executive planning characteristics of this aspect of working memory - the speech production factor were expected. Only when these two sets of expected relations could be incorporated into a statistically sufficient (i.e., strong) model were the relations of visual-sequential working memory to the different language factors considered. Given that the language factors intercorrelated among themselves, examination of whether the relations between the language factors themselves produced additional predictive relations and thus merited inclusion in the model was also examined.

Model 1 is based upon the final results of the confirmatory regression analyses and is presented in Figure 2. Only those connections and relations which were statistically retainable are thus included in this model. As can be seen, all three aspects of working memory and the four language factors are positioned in this model which was found to have a good fit: χ^2_{180} = 247.057, p = 0.001, AGFI = .77, NFI = .79 and RMSEA = 0.062.

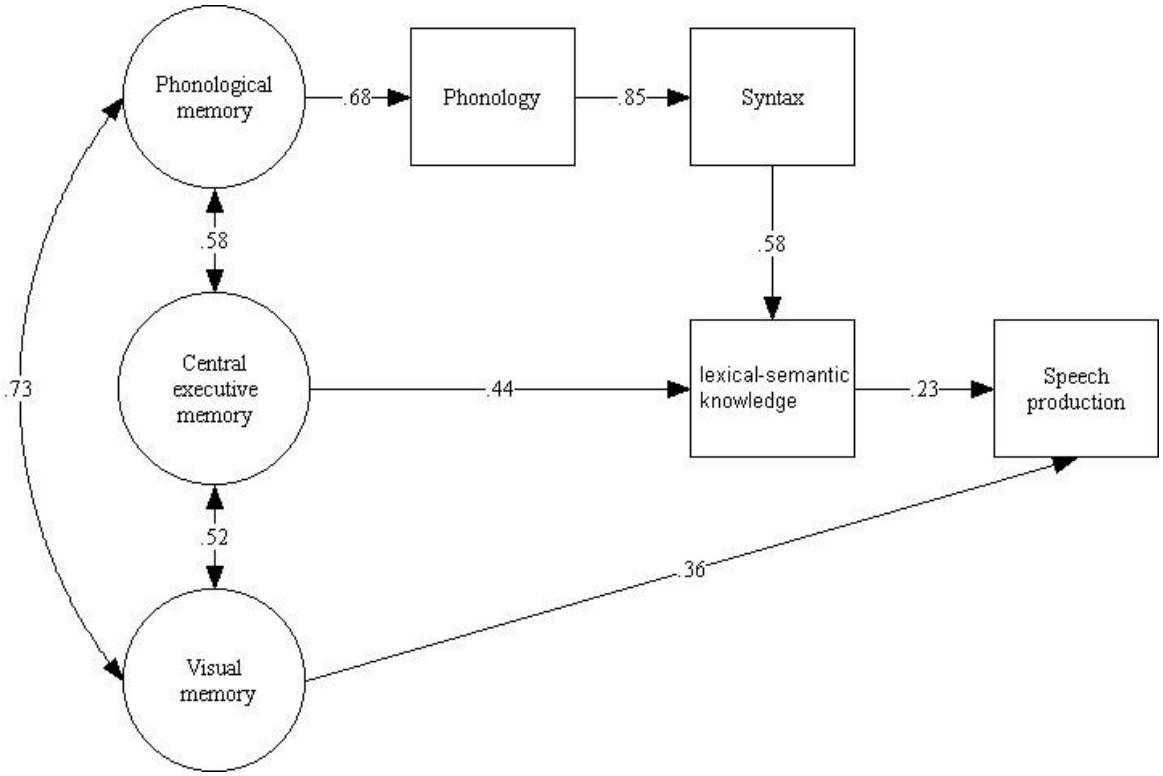

Figure 2: Structural equation model for memory and language factors.

Closer inspection of the model shows the three aspects of working memory to clearly relate to each other, with the phonological and visual aspects relating most strongly. The phonological aspect of working memory shows a clear relation - in keeping with our expectations - to phonological language abilities (.68). The central-executive aspect of working memory relates to lexical-semantic knowledge abilities (.44). And in our exploration of the possible relations of visual working memory to language abilities, we found a significant relation to the speech production abilities of the SLI children studied here (.36).

Phonological ability shows an important relation to receptive syntactic abilities (.85). And (receptive) syntactic abilities show an important relation to the lexical-semantic knowledge abilities of the SLI children studied here (.58). Finally, lexical abilities show a weak relation to speech production (.23). The relations found resemble the relations between auditory speech perception, receptive language processing, expressive language processing and speech production in the adult psycholinguistic model outlined by Levelt (1989).

Conclusions

A number of conclusions can be drawn on the basis of the results of the present study. With regard to the question of how the children with SLI score on various working memory and language tests relative to their peers with normally developing language, the results show the performance of the children with SLI on two of the three aspects of working memory to be significantly weaker. The results reveal developmental problems with respect to the central-executive and phonological aspects of working memory. This finding is in keeping with the now widespread evidence showing weak phonological working memory to often play a role in the weak language abilities of children. The present results do not provide sufficient statistical evidence for problems with visual working memory among the children studied here although they did score weakly on these tests. The performance of the SLI children on all of the language tests was considerably and significantly weaker than that of their peers with normally developing language. This finding should be considered in light of the research population, which involved children attending special schools for children with severe auditory and/or communication problems. Epidemiologically, less than 0.5% of 5-year old children attend such schools in the Netherlands. The major delays on the language tests are thus, in this light, not unexpected.

The second research question concerns the factors which appear to constitute the working memory and language abilities of children with SLI. The three aspects of working memory demonstrated here were of a similar nature and modality as those described in the model of Baddeley. The two basic types of working memory, namely the visual and auditory, both have a sequential aspect within the present study. Despite this shared characteristic, the two factors could still be distinguished. Evidence for the third factor, namely a more

central-executive working memory, was also found. The present findings thus fit with the growing conviction that information-processing problems may indeed play a role in specific language acquisition problems (e.g., Hoffman & Gillam, 2004). With regard to the children's language abilities, four distinct factors were found: phonology, syntax, lexical-semantic knowledge and speech production. The problems detected in the phonological domain fit with the findings of many other studies showing children with SLI to indeed have such phonological problems (e.g., Benasich & Tallal, 2002; Hartley & Moore, 2002; Tallal, Allard, Miller, & Curtiss, 1997). Similarly, there is considerable evidence already available for the syntactic and speech production problems detected here (Bishop, 2004). The language factors also correspond to the picture painted by classification studies concerned with English-language samples of children with language disorders (e.g., Rapin, 1996).

The preceding brings us to the most important research question within the context of the present study, namely how the working memory and language abilities of children with severe speech and language problems appear to relate. This question was answered by examining which statistically significant connections existed between the different aspects of working memory and the different language factors for the children with SLI. The phonological aspect of working memory showed reasonably high correlations with all the language factors. The same was found for the visual aspect of working memory with the exception of the speech production factor. And the central-executive aspect of working memory correlated highly with the lexical-semantic knowledge abilities of the children and, to a lesser extent, with their syntactic and phonological abilities.

The interrelations between the various factors were further examined with the aid of structural-equation modelling (SEM). A strong relation was found between phonological working memory and the phonological language factor. It seems warranted to state that a common sequencing ability underlies this relation. This phonological sequencing ability constitutes an important basis for the processing of longer and more complex sound input in the form of phrases and sentences (see, among others, Leonard, 1998; Joanisse & Seidenberg, 2003, for reviews). The model found to fit the data in the present study similarly reveals such an indirect relation between phonology and receptive syntax. A direct relation between phonological working memory and the receptive-syntactic language abilities of the children was also sought, but this was found to only decrease the goodness-of-fit for the model. The influence of phonological working memory may thus operate via phonological abilities. This is consistent with insights that children can learn language from the regularities in the phonological information provided in the input.

A relation between central-executive working memory and the lexical-semantic knowledge factor was expected due to the shared conceptual aspect, and such a relation was indeed found for the children's lexical development. An explanation for this finding can

be found in connectionist models of memory and language and also in the fact that those process which have to do with the central-executive memory functions and those processes responsible for the building of the mental lexicon are of a relatively complex nature and may therefore require both bottom-up and top-down information processing. On the other hand these working memory tasks and the lexical tasks might share a common mechanism responsible for maintaining lexical-semantic information (see Alloway & Gathercole, 2005). Central-executive working memory relates only indirectly to the speech production factor while visual working memory has a weak relation to speech production. This last finding is in line with the study by Pickering and Gathercole (2004). In their study children with problems specific to language had impairments of the phonological loop and the central executive only. Because of its weak significance, leaving out visual memory from model 1 did not change the model fit, so we chose to visualize visual memory in our model to challenge further research on this point.

The relations found here should be interpreted with utmost caution. The dual influence of the visual information processing system and the language system, however, is very compatible with the dual coding theory of Paivio (Paivio, 1986; Clark & Paivio, 1991), which describes just how visual and verbal information processing work together in the conceptual-cognitive development of young children. And the fact that such a joint contribution is still found in the 5-year-old children with severe language problems studied here suggests points to the possibility of delayed neurolinguistic development. Further investigation is needed, for instance concerning the relation between the central-executive memory and lexical-semantic knowledge using experimental memory tasks.

In addition to the relations between the various aspects of working memory and the children's language abilities, the regression model also reveals a relation between the syntax factor and the lexical-semantic knowledge factor. This connection between syntax and semantic interpretation is referred to as syntactic bootstrapping by Gleitman (1990). And central to the syntactic bootstrapping proposition is the hypothesis that children may make use of syntactic information in the learning of new words. The underlying thought is that children can predict the meaning of a word at least in part by analyzing the argument structure of the sentence in which the word is used. The relations between the syntax of a language and the lexicon or what we refer to as the lexical-semantic knowledge factor within the present study are considered inseparable by Bates and Goodman (1997) and have been the topic of previous studies of children with SLI (e.g., Carr & Johnston, 2001; Eyer, et al., 2002; Rice, 2000).

Some limitations on the present study

The research conducted here contributes to research focussed on relations between information processing problems and language acquisition problems of children. The findings of our study should obviously be examined in light of just how the particular aspects of working memory were operationalized. Because we chose to use only psychometrically reliable instruments, the choice of a central-executive memory test was limited. And because names had to be recalled in the name learning test, at least part of the relation to a lexical-semantic factor was predetermined. With respect to the visual working memory tests, the performances of the children on the concrete versus abstract pictures were found to greatly differ. This means that only weak internal consistency was found for this factor and that the conflicting relations to the speech production factor can thus be possibly explained. Follow-up studies with the broadest possible operationalization of visual working memory is therefore called for in the form of an extensive neuropsychological test battery in which the tasks tap the different memory components as purely as possible. The recently developed working memory test battery for children (Pickering & Gathercole, 2001) seems in this case to be a perfect example. The different language abilities as distinguished in the present study were also not studied to an equally broad extent. In future studies concerning language and working memory more extensive study of central auditory processing and expressive syntactic abilities based on, among other things, linguistic analyses of spontaneous language expressions is therefore recommended. Finally, with respect to the population of children examined in the present study, a group of children with severe language acquisition problems was selected from actual clinical practice. All of the children in the present study received specific interventions, but exactly which specific intervention each child received and the duration of the intervention was often unclear. Intervention effects may have influenced the present data and, for this reason, certain relations may not have been very apparent or clear. And a plea is therefore made for greater longitudinal research in the future. In longitudinal research, initial problem domains can be identified; the course of their development can be mapped; and the actual effects of the interventions can be measured. Such research is also a necessary contribution to disentangle cause and effect in respect to language deficits and working memory problems (see Bishop, et al., 1996).

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Chapter 5.

Behavior Problems in Children with Language Impairment[1]

Abstract

Background: Language impairment is often associated with behavior problems. However, detailed relations between different types of language impairment and specific behavior problems in children have yet to be demonstrated. The present study attempted to do just this with an eye to the implications to identify foci for early intervention. **Methods:** The language abilities of 71 five-year-old children with language impairment were assessed via the administration of an extensive battery of language tests. The children's behavior profile was assessed via administration of the Child Behavior Checklist. **Results:** Factor analyses confirmed the presence of four language factors: speech, syntax, semantics and phonology. Forty percent of the children displayed serious significant behavior problems. The most frequently occurring behavior problems were: withdrawn behavior, somatic complaints, thought problems and aggressive behavior. Behavior problems were associated with three of the four language factors but not strongly associated with speech problems. **Conclusions:** Differential relations between specific types of language impairment and specific behavior problems already exist at a young age. Phonological problems showed broad relations to problem behavior, semantic language problems were especially related to internalizing behavior problems. This finding suggests the need for specific therapies for both different types of language problems and for different types of behavior problems. **Keywords:** Language impairment, child language disorders, classification, behavior problems, Child Behavior Checklist, child development.

Introduction

The results of decades of research show that behavior problems often accompany language impairments (LI) (cf.. Beitchman, et al., 1996; Rogers-Adkinson & Griffith, 1999; Tallal, Dukette, & Curtiss, 1989). Behavior problems can be distinguished into internalizing versus externalizing problems (Achenbach & Edelbrock, 1978, 1983; Koot, Van Den Oord, Verhulst, & Boomsma, 1997), social problems and cognitive problems.

Externalizing behavior problems, such as delinquency or aggression, among children with LI are generally reported by speech-language pathologists (Sanger, Moore-Brown, Montgomery & Hellerich, 2004).

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Internalizing behavior problems among children with LI such as anxiety, limited emotional regulation skills, withdrawn behavior and low self-esteem have been shown to be common (Cantwell & Baker, 1987; Jerome, Fujiki, Brinton, & James, 2002; Lindsay & Dockrell, 2000; Fujiki, Brinton, & Clarke, 2002).

Social problems among children with LI are manifested in interactions problems with peers that lead to a lack of adequate role models, positive social interactions and feedback (Hart, Fujiki, Brinton & Hart, 2004; Vallance, Cummings, & Humphries, 1998). In a large-scale longitudinal study, the social and behavioral problems of 8 to11-year old children with LI were found to increase over the years (Botting & Conti-Ramsden, 2000; Conti-Ramsden & Botting, 2004).

Finally, studies of the relations between LI and *cognitive problems* have shown problems with attention/concentration, impulse regulation and information processing (e.g., Tallal et al., 1989; Javorsky, 1996; Westby & Cutler, 1994).

So far, research on the relations between LI and behavior problems has been predominantly investigated in older children with relatively advanced school careers. Within the framework of early intervention, however, it is important to study those relations at an earlier age. An additional problem with the studies conducted to date is that the language impairment is often operationalized in a unitary manner. Recent studies, however, show that LI has multiple underlying language factors or components with the following aspects: auditory perception, lexicon and semantics, syntax, speech (articulation) and pragmatics (see Bishop & Leonard, 2000; Conti-Ramsden & Botting, 1999; van Daal, Verhoeven, & van Balkom, 2004).

In the present study, the relations between different components of language proficiency and behavior problems were examined in a sample of children with LI in the Netherlands. A total of 71 children were randomly selected from special education schools for children with LI. The language proficiency of the children was measured on a broad basis and thus included the domains of auditory perception, speech, syntax, lexical-semantics and pragmatics. In addition, various aspects of the behavior of the children were examined with the aid of the Child Behavior Checklist (CBCL; Verhulst, Koot, Akkerhuis, & Veerman, 1990). Specific factors of language problems were distinguished, the incidence of different types of behavior problems were determined and the extent to which the language factors and behavior problems related to each other was analysed. In sum, answers to the following three research questions were sought.

1) What does the language proficiency profile for five-year-old children with LI look like and can the language factors speech, phonology, lexical-semantics and syntax (cf. van Daal et al., 2004) be distinguished?
2) To what extent do the children show behavior problems?

3) What are the relations between the underlying language factors and behavior problems observed?

We expect that children with weak phonology skills will show many relations with different behavioral problems since phonological processing may be seen as an important first-stage process in language learning (Bishop, 1997; Levelt, 1989). Semantic and pragmatic language problems are often seen in autistic children, so we expect semantic language problems to be related to internalizing behavior problems (Rapin, 1996).

Method

Subjects

The study received ethical review by the 'Dutch Research & Development platform Language problems'. The subjects were randomly recruited from special schools for children with LI in the Netherlands after obtaining the written consent of the parents. Children were only admitted to these schools when they showed normal to below average nonverbal intelligence, weak language scores on criterion-referenced tests (i.e., scores two standard deviations below the mean), no sensory-motor deficits and no psychiatric disorders. A total of 71 five-year-old children (i.e., 51 boys and 20 girls) were selected to participate. The children formed part of a larger sample of 97 children who were randomly selected from 29 schools for children with LI. For the present study only children from the 22 schools in which behavior data among parents had been collected were included. Children with an autistic spectrum disorder didn't participate in the study because of the inherent comorbidity of language and behavior problems of autism. This was also the case for bilingual children, children with hearing problems or practical intelligence quotient (PIQ) lower than 75. The mean test age was 64 months (Range 59-69, SD 2.04).

Test procedure and measures

Behavior of the child was assessed with the Dutch version of the CBCL (Verhulst, Koot, Akkerhuis, & Veerman, 1990). Extensive documentation of not only the test-retest intra-rater reliability as well as the inter-rater reliability of the behavior questionnaire is available (e.g., Embregts, 2000; Verhulst et al., 1990). The questionnaire consists of 113 items constituting 8 subscales. The Withdrawn, Somatic Complaints and Anxious/Depressed subscales taken together constitute the Internalizing scale. The Aggressive Behavior and Delinquent Behavior subscales constitute the Externalizing scale. The remaining subscales are Social Problems, Thought Problems and Attention Problems. Clinical levels of problematic behavior are defined when the behavior occurs with the same frequency in 2% or less of the norm group. Borderline problematic behavior is defined when the behavior occurs with the same frequency in 5% or less of the norm group. Parents were asked to rate

their children's behavior as they have known their children for much longer and see their children across a wider variety of situations than teachers.

The children's language proficiencies were assessed at their schools. The tests and tasks were selected to measure speech, auditory perception, conceptual/lexical knowledge and other such specific linguistic capacities as morphosyntactic skill, semantic development and pragmatic communication. Speech was tested using the five experimental dyspraxia tasks (Maassen, 1999) and the articulation task from the general Dutch language test – the Taaltoets Alle Kinderen (*TAK*, Verhoeven & Vermeer, 2001). Auditory perception was measured using the sound discrimination test from the Dutch *TAK* and the Dutch experimental version of the Lindamood Conceptualization test (LAC) (Simkens, 1999; Lindamood & Lindamood, 1971). All of the other language tasks from the TAK - with norm groups of approximately 500 typically developing children for each year in the age range from 4 to 8 - were also included in the present language test battery in order to assess as many different aspects of the children's language proficiency as possible (see Table 1 for overview of test information).

Data analysis

In order to answer the first research question, the descriptive statistics for the language battery were calculated. T-tests were conducted to compare the performance of the children with LI to the normative data provided in the various test manuals. Confirmatory factor analyses using the AMOS 5.0 program (2003) were undertaken with the language data to look for statistical evidence for four different language factors. In order to answer the second question, composite-scores of the child behavior ratings provided by the fathers and the mothers were examined. To answer the third question, the correlations between the different language factors and the total CBCL scale scores and subscale scores were calculated.

Results

Descriptive language statistics

The results of the children with LI were compared to normative data by calculating t-tests for differences between the means for two independent samples (see Table 2). The results of the t-tests showed significant differences between the mean scores of the research group and the norm group in all cases. On most of the tasks, the delay was one to two standard deviations, on two tasks (phonological discrimination and articulation tasks) even more. On two tasks (sentence comprehension and word production tasks) the delay was less than one standard deviation.

TABLE 1. Overview of the test battery.

Type of test/task	Abbreviation	Name of test/task	Brief description of the test
Speech	AT	Articulation test TAK*	Repetition of 45 short words.
	DYS1	Picture Naming* (α = .86)	Naming 8 pictures of normal objects.
	DYS2	Nonsense Word Repetition 1*(α = .76)	Repetition of 12 nonsense words (consonant-vowel (CV) or CVVI syllables)
	DYS3	Word Repetition 1* (α = .62)	Repetition of 10 complex words.
	DYS4	Nonsense Word Repetition 2* (α = .82)	Repetition of 11 nonsense words; (containing 3 CV syllables using only the vowel /a/ (e.g., 'sa-pa-da') .
	DYS5	Word Repetition 2* (α = .89)	Repetition of 15 contrasting word pairs (pairs have CVC structure differing on one of the consonants.
Syntax	SC1 & SC2	Sentence Comprehension tests TAK 1&2	Choosing one of three pictures corr4esponding with sentence presented. (42 items)
Semantics	SR	Sentence Repetition test TAK*	Repetition of 20 sentence elements.
	WP	Word production test TAK	Eliciting word endings by means of pictures and incomplete sentences (24 items).
	NT	Narrative tests TAK*	Storytelling on comic strips, content (meanings and relations) is scored.
	RV	Receptive Vocabulary test TAK	Choosing one of four pictures after hearing a word (96 items).
	PV	Productive Vocabulary test TAK	Naming of pictures (60).
	WD	Word Definition test TAK*	Defining words by the child.
	SCT	Story Comprehension test TAK	Stories are read aloud, child has to answer questions about the content of the story.
Phonology	LAC	Experimental Dutch version of the Lindamood Auditory Conceptualization test	Reproducing sequences of phonemes by matching in correct order coloured blocks to specific phonemes
	PD	Phonological Discrimination test TAK	Telling if pairs of short words are the same or not . The word pairs differ with respect to one phoneme.
Pragmatics	CCC-1	Children's Communication Checklist 1	Experimental Dutch version of the CCC-1 (Bishop, 1998) as developed by Hartman et al. (1998)

* = test was audio recorded. α = Cronbach's reliability coefficient.

TABLE 2. Mean language scores for research group and norm group.

	Research group			Norm group		
	Number of items	M	SD	M	SD	T
Language[a]						
RV	96	45.29	13.80	66.17	13.09	12.03**
PD	50	35.83	7.66	46.10	5.05	14.40**
AT	45	26.38	11.17	43.84	2.00	31.45**
WD	45	7.71	4.71	18.84	6.25	13.85**
SR	20	9.40	7.86	29.40	8.23	18.52**
NT	16	11.17	5.87	18.23	6.46	8.37**
SUM of SC1a to SC1d[b]	42	28.06	5.97	33.15	5.13	7.38**
SUM of SC2a plus SC2b[b]	42	27.45	6.54	31.42	5.29	5.53**
WP	24	9.00	4.83	11.85	6.10	3.62**
SCT	24	13.31	5.11	17.91	4.38	7.81**
PV	60	23.92	9.86	31.85	8.20	7.16**
LAC 1a	10	5.31	3.67	9.00	1.70	13.83**
LAC 1b	6	1.66	1.83	4.00	2.00	8.96**
LAC 2	12	1.22	1.38	2.10	2.60	2.68**

Note. N = 65 for research group; N = 500 for TAK and LAC norm groups. [a] No norm group scores available for speech tests DYS1 through DYS5. Also no Dutch scores available for pragmatics test CCC-1. [b] Subtest data not available for normal population. ** $p < .01$.

Underlying language factors

Confirmatory factor analyses on the language variables were undertaken to explore the factorial language structure. For a confirmatory factor analysis (CFA), variables are assigned to a particular factor a priori. Using AMOS 5.0 for structural equation modelling (SEM) analysis, the plausibility of the language factor model is estimated. The language variables used in this analysis were chosen on the basis of the results of previous study (van Daal et al, 2004). The best fitting factor model, using Hu and Bentler's cut-off criteria (Hu & Bentler, 1999), showed the observed language variables to be represented by four language factors: *speech, syntax, lexical-semantics and phonology*. The goodness of fit measures were quite satisfactory: $\chi^2_{84} = 113.45$, $p = 0.018$ and RMSEA = 0.074. Correlation between factors was admitted to obtain this CFA-model. The results in Table 3 show the distribution of the different tests/tasks across the four factors and the associated factor loadings. (CFA with AMOS computes factor loadings for variables incorporated in the CFA-model).

Table 3. Results of confirmatory factor analysis for speech-language tasks.

TASK	*Syntax*	*Semantics*	*Speech*	*Phonology*
SC1a	.82			
SC1b	.69			
SC1c	.42			
SC1d	.72			
SC2a	.78			
SC2b	.84			
WD		.54		
PV		.72		
RV		.78		
WP		.68		
DYS1			.89	
DYS3			.83	
AT			.77	
LAC				.67
PD				.59

The different sentence comprehension tasks are subsumed under the first factor. This factor concerns receptive grammatical language proficiency and is thus referred to as *syntax*. The tasks subsumed under the second factor require the child to understand or express meanings. On three of the four tasks, the semantic information is conveyed via a word (i.e., vocabulary); on the fourth task, the semantic information is conveyed by an entire sentence. The second factor thus concerns *lexical-semantic* language skills. The third factor encompassed the speech dyspraxia tasks which require the repetition of words. The main underlying factor is thus *speech*. Finally, the fourth factor was defined by two tasks which measure speech perception. The main underlying skill in this case is thus *phonology*.

Descriptive behavior statistics

Of the total research group, CBCL data could be collected from 65 (92%) of the families: 64 mothers (91%) and 59 fathers (83%) completed the behavior questionnaire. In four families no questionnaire was filled in because the family moved away, in two cases parents declined to complete the questionnaires. There is no reason to believe that this small reduction of data influenced the way of sampling in any systematic way. The means and standard deviations of the CBCL ratings provided by the fathers and mothers are presented in Table 4.

In order to determine the extent to which the judgements of the fathers and mothers with regard to the behavior of their children agreed, the intra-class correlations (ICC, Guilford, 1954) between their judgements were calculated. The ICC scores for the total, total internalizing and total externalizing scale scores were about .81, .80 and .80, respectively, and can thus be considered acceptable (Kazdin, 1980). A high level of concordance between ratings of two parents is also reported by Verhulst et al. (1990). Given these ICCs, it was decided to adopt a composite score (i.e., the mean of the ratings provided by the father and the mother) for the children who had scores from both parents. In order to determine the rate of problematic behavior, we counted the children that had a clinical or borderline score from the mother *or* the father. As can be seen in Table 4, 40% of the total CBCL behavior scores for the children were found to fall within the clinical range or borderline range. The incidence of internalizing behavior was 20% clinical and 7.7% borderline. The incidence of externalizing behavior problems was 13.85% clinical and 13.85% borderline. With regard to the individual subscales, there were relatively high percentages of occurrence for the Withdrawn, Somatic Complaints, Thought Problems and Aggressive Behavior subscales.

Relations between language proficiency and behavior scores

The correlations between the four language factors and the CBCL behavior problem scores are presented in Table 5. A negative correlation indicates that lower performances on the language factor score are related to a greater occurrence of behavioral pathology.

The *syntax* factor showed medium ($r > .30$) to large ($r > .50$) (see Cohen, 1988) correlations with the CBCL subscales of social problems, thought problems, attention problems and also the total CBCL score. The *semantics* factor showed large correlations with two of the same CBCL subscales: social problems and attention problems. This factor showed medium correlations with: withdrawn behavior, anxious/depressed and thought problems, total-score and total-internalizing score.

The *speech* factor showed one medium correlation with social problems. Finally, the *phonology* factor showed large correlations with: social problems and attention problems and medium correlations with withdrawn, anxious/depressed, thought problems, delinquent behavior and aggressive behavior, total-score, total-internalizing score and total-externalizing score.

Table 4. Means and standard deviations for CBCL ratings by mothers (M) and fathers (F) and numbers and percentages of clinical and borderline cases[1]

CBCL scales		Mean	SD	Clinical	Borderline	Total
Withdrawn	M	57.78	8.67	9 (13.83 %)	3 (4.62 %)	12 (18.46 %)
	F	55.63	6.99			
Somatic Complaints	M	56.00	8.33	6 (9.23 %)	6 (9.23 %)	12 (18.46 %)
	F	54.44	6.59			
Anxious/Depressed	M	52.92	5.53	1 (1.54 %)	3 (4.62 %)	4 (6.15 %)
	F	51.32	2.94			
Social Problems	M	57.27	6.44	2 (3.08 %)	3 (4.62 %)	5 (7.70 %)
	F	54.95	5.38			
Thought Problems	M	57.28	9.66	9 (13.85 %)	0	9 (13.85 %)
	F	55.44	7.13			
Attention Problems	M	56.31	7.35	6 (9.23 %)	1 (1.54 %)	7 (10.77 %)
	F	54.39	5.46			
Delinquent Behavior	M	52.72	4.61	0	2 (3.08 %)	2 (3.08 %)
	F	52.00	4.01			
Aggressive Behavior	M	56.11	7.60	4 (6.15 %)	4 (6.15 %)	8 (12.31 %)
	F	55.08	6.51			
Total score	M	54.97	11.14	20 (30.77)	6 (9.23 %)	26 (40 %)
	F	52.39	9.41			
Total Internalizing	M	52.59	10.55	13 (20 %)	5 (7.70 %)	18 (27.69 %)
	F	50.47	9.70			
Total Externalizing	M	51.67	10.84	9 (13.85)	9 (13.85 %)	18 (27.69 %)
	F	50.58	10.10			

[1] Clinical : subscales T ≥ 70, total scores T ≥ 64 [2] Borderline : subscales T ≥ 67 up to 70, total scores T ≥ 60 up to 64. N = 65

Table 5. Correlations between general language factor scores and behavior problem scores.

	Withdrawn	Somatic Complaints	Anxious Depressed	Social Problems	Thought Problems	Attention Problems	Delinquent Behavior	Aggressive Behavior	TOTAL	INT	EXT
Syntax	-.11	-.02	-.17	-.42**	-.20*	-.44**	.02	-.11	-.26*	-.15	.10
Semantics	-.34**	-.18	-.22*	-.55**	-.26*	-.49**	.02	-.12	-.36**	-.34**	-.11
Speech	-.19	.04	-.10	-.23*	-.01	-.16	.11	-.10	-.14	-.12	.08
Phonology	-.24*	-.09	-.26*	-.49**	-.40**	-.53**	-.25*	-.20*	-.40**	-.28**	-.21*

* = $p < .05$; ** = $p < .01$

Conclusions and discussion

Language profiles

As expected, the LI sample had significantly lower scores than the age norm groups on all of the components of the language test battery. Confirmatory factor analysis supported a four language factor solution. This provides empirical cross-linguistic support for theoretically clearly distinguishable language factors: language proficiency of children with LI seems to be quite multidimensional. This finding corresponds to the findings of other classification studies, both psychometric studies (e.g., Aram & Nation, 1975; Conti-Ramsden, Crutchley, & Botting, 1997) and clinical studies (e.g., Haynes & Naidoo, 1991; Rapin, 1996; Rapin & Allen, 1992). Four factors could be distinguished: syntax, lexical-semantics, speech and phonology. The factors in our CFA-model were correlated which is in keeping with current neurocognitive models of language comprehension and language production which provide evidence for the fact that coordinated phonological processing networks are involved in both speech perception and speech production (Guenther & Perkell, 2004), and that phonology, semantics and syntax work in parallel in unification operations during on-line sentence processing (Hagoort, 2005).

Behavioral profiles

In 40% of our sample a behavioral problem was indicated by at least one parent. In about 30% of the sample, behavior was qualified in the clinical range and in another 10% in the borderline range. Closer inspection of the data showed that internalizing and externalizing problems tended to occur to the same extent. Withdrawn behavior and somatic complaints predominated as internalizing problems and aggressive behavior as the externalizing problem. In addition, thought and attention problems were reported and to a lesser extent social problems. Comparison to the results of earlier studies in which the behavior of children with language learning problems has also been examined using the CBCL shows that our results are largely in keeping with the findings of Willinger et al., (2003) while falling in between studies that found higher rates (Beitchman, Nair, Clegg & Patel, 1986; Coster, 2001; Noterdaeme & Amorosa, 1999) and studies that report lower rates (Tallal, et al., 1989). The differences in rates may be due to sample-differences such as sample-age and definition of language impairment.

The relations between language and behavior

Differential relationships between language factor scores and behavior problem scores were found. Children's total scores on the CBCL were significantly related to the language factor scores for phonology, semantics and syntax. The correlations with phonology and semantics were higher than with syntax. These relations are consistent with

the growing evidence from neuroscience that phonology and semantics play a crucial role in the storage and retrieval of linguistic information during the early stages of language acquisition (Sakai, 2005; Hagoort, 2005), processes children in our sample still seem to have trouble with mastering.

Internalizing problems were associated with phonology and semantics. Both withdrawn and anxious/depressed behavior showed significant relations with the two language factor scores. This finding seems similar to what is seen in children on the autistic spectrum. This relation between language and socially withdrawn behavior is related to the debate about whether language disorders are intrinsic to autism (Allen & Rapin, 1992). Children with LI and autism both need therapeutic interventions to remediate their withdrawn behavior.

Externalizing problems, i.e. the occurrences of both delinquent and aggressive behavior, were found to be related to phonology only. This conforms to findings from previous studies showing that at young age levels such behavior problems are only globally related to language disorders (Sanger, et al., 2004).

Social problems were also related to language problems. This is in line with previous studies showing that social relationships are a major concern for children with language impairment (Beitchman, et al., 1996b); Brinton & Fujiki, 1999; Conti-Ramsden, et al., 2004; Coster, 2001). Conti-Ramsden, et al. (2004) correctly asserts that the combination of social problems with otherwise little aggression or rule-breaking behavior may lead to insufficient detection of behavior problems of children with language problems.

We found that the cognitive processes ‘attention’ and ‘thought problems’ were related with phonology, syntax and semantics factor scores. This finding seems to account for the fact that the language system operates in the context of communicative intentions and actions (cf. Levelt, 1989; Hagoort, 2005). Attentional control and thought regulation allow children to speak in communicative settings, provided that the language system is intact. Behavioral studies have indeed shown that impairment in any of the language modules may lead to an overload of working memory in tasks which call on information processing abilities on the part of the child (cf. Gillam, 2004). The fact that attention problems and thought problems showed a clear relationship with language problems may also point to shared neurodevelopmental factors leading to a basic temporal processing deficit (cf. Tallal, et al., 1989; Tallal, 2000).

Phonology problems were related to all of the aforementioned aspects of behavior problems. Probably many of the children in our sample had weak phonological skills. These skills play an important role in language acquisition.

Speech problems were only minimally associated with behavior problems. Only a weak, albeit significant, correlation with social problems was observed. Apparently, the

speech articulation problems we assessed do not have a great impact on children's behavior. This is consistent with the results of some other studies that show that children with only speech articulation problems are found to show the fewest psychological problems and produce relatively fewer CBCL clinical or borderline total scores (Baker & Cantwell, 1982; Beitchman, Hood, Rochon & Peterson, 1989). We also know from previous research that speech problems frequently occur at an early age, and that children tend to overcome such problems quite rapidly (Goorhuis-Brouwer, 2003). The speech problems of the children in our sample could be due to oral-motor difficulties or a weak phonological repertoire. Perhaps isolated articulation problems won't show clear relations with behavior problems.

Some possible limitations on the present study

The present study provides cross-linguistic replication of the language factors and their relation with different types of behavior problems. However, a number of possible limitations should nevertheless be mentioned. The questionnaire method used is considered to be a screening instrument. In order to draw clearly substantiated conclusions with regard to the relations between language and behavior, a clinical evaluation of the behavior should be attained in the form of, for example, a DSM-IV classification by a clinical psychologist or psychiatrist. Further study using multiple research instruments is also needed to clarify the picture of such aspects of behavior as anxiety, social problems and attention problems, using multiple raters. In our study we only used parent ratings, not ratings of, for instance, teachers. Yet another limitation on the present study concerns the collection of the information on a single occasion. One particular aspect of the present study is the young age of the sample being used. In order to be able to find out the role of age in the relationship between language impairment and behavior problems the present data should be counterbalanced with similar data in both younger and older age groups. Furthermore, language and behavior should not be seen as static but as dynamic entities, which are constantly developing and shifting under the influence of age, environmental factors, intrinsic factors and so forth. Such complex interactional relations and developments are described in the transactional model of Prizant (1999). It should also be kept in mind that our present data on the relationship between linguistic abilities and behavioral profiles are purely correlational. In order to be able to arrive at more final conclusions as regards the causal direction of the relationships being found we are in need of longitudinal studies in which the occurrence of behavioral patterns in the course of time can be related to the children's language impairment. Some other methodological concerns should also be mentioned. In the present study no control group was used and no other relevant information such as socio-economic status (SES) or intelligence-quotient (IQ) was collected to look for other possible explanations for the behavior problems of the children. Moreover, the present sample was

too small for further in-depth analysis of subgroups of children with severe delays on one or more of the general language factors.

Practical implications

In the present study problematic behavior patterns were detected in a sample of young children with LI. These problems may be the result of an underlying neurobiological problem in at least some of the cases. In other cases, the behavior problems may be reactive in nature and the result of severe language problems and thereby interaction problems. These behavior problems can be the first signals of psychiatric problems in later adult life (Clegg, Hollis, Mahwood, & Rutter, 2005). Diagnostic assessment of young children with LI should therefore include their behavior profile. Specific therapies with respect to the behavioral aspects of the child's functioning, such as training social behavior or cognition, can then be applied. Omission of the above can lead to severe behavioral disturbances, psychiatric problems and social breakdown (see Beitchman, Cohen, Konstantareas, & Tannock, 1996a).

Supplementary material

The following supplementary material is available for this article: Appendix (Word document) This material is available as part of the online article from: http://www.blackwell-synergy.com/doi/abs/10.1111/j.1742-4658.2006.01790.x (This link will take you to the article abstract). Please note: Blackwell Publishing are not responsible for the content or functionality of any supplementary materials supplied by the authors. Any queries (other than missing material) should be directed to the corresponding author for the article.

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Chapter 6

General conclusions and discussion

In this dissertation, the results of a longitudinal study in the Netherlands of 110 children for which one can speak of SLI between the ages of four- and six-years of age are reported. The scores of the children on various language tests across three measurement occasions showed significant delays for all language components relative to peers with no SLI. The deviations from the peer means varied from one standard deviation to more than three standard deviations. The delays with respect to the components of the tests concerned with speech production and auditory conceptualization were greatest. Of the original 110 children, the language skills of 24 developed sufficiently to all them to leave the special education schools during the course of the study. When the possibility of these children constituting a special group and biasing the results of the initial – exploratory - factor analyses was considered, this was not found to be the case. On the first measurement occasion, the subgroup of children who would later leave the special education school showed language problems that were comparable to those of the other children. This subgroup of 24 children developed more favorably across a period of two years than the other children. In contrast, the results show the size of the delays on the language tests for the children who continued to attend the special education school to remain the same across the three measurement occasions. Taken together, these results show the original sample to indeed be composed of children with severe language development problems and that one can speak of persistent problems for the majority - approximately 75% - of the children. Such a group of children with persistent SLI can also be encountered in other longitudinal studies in which, among other things, persistence up to a later age and possible associations with learning problems, psychosocial problems, and heredity are described (Bishop, Price, Dale, & Plomin, 2003; Heim & Benasich, 2006; Nation, 2005; Stothard, Snowling, Bishop, Chipchase, & Kaplan, 1998).

Subtypes of SLI

The hypothesis that the language skills of children with SLI at the ages of four, five, and six years are of a multifactorial character was confirmed by the results of the different studies described in this dissertation. With the aid of both exploratory and confirmatory factor analyses, four separate factors were consistently distinguished for the language skills of the children with SLI studied here. The four language factors also proved stable over time. That is, the same four factors were distinguished on all three measurement occasions. The classification of language problems should be differentiated from the classification of *children*

with language problems. More specifically, some of the children in the research population showed problems with one of the four language factors on a particular measurement occasion while other children showed problems with two or more language factors on a particular measurement occasion. That is, the number and nature of the language problems identified for the children on one and the same measurement occasion could vary greatly across children.

The present studies thus revealed a four-factor classification system for the language skills of Dutch-speaking children with SLI in the age range of four to six years. The four language factors were labeled according to the nature of the language skills called upon by the tasks loading highest on the relevant factor, which resulted in the following factor labels: *phonology (auditory perception), lexical semantics, syntax (syntactic-sequential proficiency)*, and *speech production*.

In a different Dutch study conducted parallel to the present study but with a population of children between six and ten years of age, factors comparable to the factors identified in the present study were also found (van Weerdenburg, 2006). The classification identified in the present study is also strongly comparable to the classification described by Rapin (1996). Only the semantic-pragmatic disorder described in the work of Rapin could not be identified in the present study, which is not surprising in light of the fact that our test battery did not include very many tasks of a semantic-pragmatic nature. The classification identified in the present research also fits that of Bishop (2004) who pleads for differentiation of the language problems of children along the following lines: typical SLI or primarily grammatical and/or semantic language development problems; developmental verbal dyspraxia or speech production problems stemming from problems with the mental representation of sounds and sound segmentation problems; severe auditory-receptive language disorders, which are rare but can stem from the Landau-Kleffner syndrome, for example; and finally pragmatic language disorders or problems with the use of language in social contexts.

The relations between the different types of language skills or four language factors identified in the present research have also frequently been the topic of study in previous research on children with SLI. Phonological problems are generally considered an important factor in SLI and a possible cause of the problems of young children in the area of grammatical language competence, for example (Joanisse & Seidenberg, 2003). Deficient auditory perception localized in the temporal area of the cerebral cortex may possibly be the cause of the more general language development problems of children with SLI and thus a promising candidate for training (e.g., Tallal & Piercy, 1973; Fitch, Miller, & Tallal, 1997; Bishop & Carlyon, 1999; Gillam, Frome Loeb & Friel-Patti, 2001). In addition, considerable research has been done during the past decade on the lexical and semantic problems of

children with SLI (e.g., small vocabularies, word-findings problems, or mistaken word understanding/use) (e.g., McGregor, Newman, Reilly, & Capone, 2002; Windfuhr, Faragher, & Conti-Ramsden, 2002; Ellis-Weismer & Hesketh, 1996). A large amount of research has also been conducted in recent years on the identity exact nature of the grammatical problems associated with SLI and, as an important question, whether the relevant language problems can be specifically distinguished for children with SLI and one can thus speak of "grammatical SLI" or the language problems are associated with other language skills such as lexical language skills (e.g., Bishop, Bright, James, Bishop, & van der Lely, 2000; van der Lely, 2005). Finally, specific speech development problems have also been studied among children. Research on motoric (i.e., articulation) problems or so-called developmental verbal dyspraxia is a specific area of attention for researchers in this field (see, among others, Kent, 2000; Bowen, 1998, 2007).

Patterns of language development in children with SLI

On the basis of the exploratory factor analyses conducted in the first study when the research group was an average of about four years of age (see Chapter 2), confirmatory factor analyses were conducted on the data from measurement occasion two when the research group was about five years of age and on the data from measurement occasion three when the research group was about six years of age. The confirmatory factor analyses were conducted with the aid of structural equation modeling (SEM). Whether or not the same four language factors could be discerned for the same population of children one and two years later was examined. The same four language factors were indeed discerned although correlations between the different factors had to be allowed, which is in keeping with the idea that the language skills of children do not develop separately from each other but, rather, interdependently (Dixon & Marchman, 2007). Again with the aid of SEM, the interrelations between the different language factors on each of the measurement occasions were analyzed separately as well as from measurement occasions two to three. The results of these analyses showed two very strong relations between measurement occasion two, for the five-year olds, and measurement occasion three, for the six year olds, namely in the domains of lexical semantics and syntax or what can be considered the classical domains of language and what Bishop (2004) refers to as "typical SLI." At the same time, a strong relation *between* the two factors was also detected for the research group at the age of five years (i.e., on measurement occasion two). Lexicon and syntax thus appear to develop in a highly interdependent manner. In the present study, a strong relation was also found between the two measurement occasions with respect to speech problems. The pronunciation problems of the research group appeared to be persistent between age five

and six. In normally developing children articulation makes a sprint at this age resolving final pronunciation (Flipsen, 2006).

The association between the factor of phonology on measurement occasion two and the factor of phonology on measurement occasion three was found to be weakest. This may be related to the fact that the administered task greatly relied upon the children's metalinguistic awareness, which is clearly limited at the age of five years and grows considerably - predominantly as a consequence of starting reading instruction - around the age of six (cf. Karmiloff-Smith, 1979). There are also indications that better metalinguistic skills promote children's lexical development (Evans, 2002), but such an association could not be detected in the present study due to the particularly strong relations between the lexical factors over time. The SEM results nevertheless showed a significant connection between phonology and lexicon for the five-year-old children. The association between phonology and syntax on this measurement occasion was strong suggesting that good phonological skills at this age were associated with good syntactic development in the present research group (cf. Joanisse et al., 2003).

Cognitive factors in SLI

Previous studies of children with SLI from clinical populations have shown problems with their cognitive development to also occur on a frequent basis. In these cases, diminished scores on intelligence tests or parts of these are seen in addition to language problems. And these findings have prompted the neuropsychological exploration of information-processing problems as possible causes of SLI. Given that considerable research has been conducted on the role of working memory in SLI, it was decided to study this aspect of children's information processing further. The extent to which the children in the research group showed delays with respect to their cognitive development and various aspects of their working memory was thus examined to start with. The relations between these delays and the language factors identified in the foregoing were then examined.

The scores on the Raven Coloured Progressive Matrices test of intelligence, which was administered when the children were an average of four years and again when they were an average of six years, corresponded in both cases to an average nonverbal IQ of 95 to 100. Inspection of the intelligence scores on tasks that specifically appealed to working memory, as reported in the study described in Chapter 4, showed the following for measurement occasion two. The scores for visual working memory were average; the scores for central-executive memory were less than one standard deviation below average; and the scores on two tasks concerned with auditory working memory were more than one standard deviation below average. With the exception of the scores for visual working memory, t-scores were all significant.

In the studies described in Chapters 3 and 4, the relations of the children's nonverbal intelligence and, more specifically, various aspects of their working memories to the language factors distinguished in the previous analyses were examined. The study of working memory limitations in connection with SLI reported in Chapter 4 showed the children's auditory working memory to strongly relate to all of the language factors. This finding is in keeping with the results of a recent study by Leonard and colleagues who found auditory working memory to be the best predictor of scores on language tests when a number of information-processing tasks were considered (Leonard, Weismer, Miller, Francis, Tomblin, & Kail, 2007). In our study, the central-executive aspect of working memory was related to the lexical-semantic language factor and visual working memory showed a weak relation to the speech factor. The results of the SEM reported in Chapter 3 further showed the digital span test of auditory working memory to be most strongly related to syntax. This finding is in keeping with the view that auditory working memory is an important link in auditory perception, for instance leading to problems with the distinction of the less conspicuous differences between sounds. A strong association of auditory memory problems with morphosyntactic problems of children with SLI has been demonstrated in different studies (Joanisse et al., 2003). Other studies question this relation, the children with grammatical problems they studies didn't have auditory working memory problems (van der Lely, Rosen, & Adlard, 2004). Although the picture isn't clear, auditory working memory at the ages of four and five years could be related to important aspects of the language development of children with SLI. Of the tasks used in the present study, the digit-span task appeared to be most sensitive to the auditory working memory problems of the children. Recent research also shows a nonword-repetition task to be sensitive to the auditory working memory problems of children with SLI (for a meta-analysis, see Estes, Evans, & Else-Quest, 2007). Basic nonlinguistic auditory perception problems thus appear to frequently occur among children with SLI. In a very recent study, in fact, an incidence of 70-80% was found among seven- to eleven-year-old children with SLI (Corriveau, Pasquini, & Goswami, 2007). Finally, the present findings also fit into the theoretical viewpoint that weak scores on auditory working memory tasks, as used in the present study, and syntactic language problems can both be explained in terms of problems with the sequential processing of information (Fazio, 1996; Hoffman & Gillam, 2004).

In the present study, nonverbal intelligence was assessed using the Raven Coloured Progressive Matrices and found to be related to three of the language factors distinguished in the factor analyses but not the speech factor. This finding suggests that, for at least the present research group, the degree of nonverbal intelligence at the age of four years is related to a limited extent to the degree of language development at the ages of five and six years. This implies that for some children with SLI, problems with nonverbal cognition at a

young age may constitute an extra warning sign for later language problems. These results must nevertheless be interpreted with caution as various studies have shown the associations between nonverbal cognition and the degree of language delay to differ widely across children (Dockrell, George, Lindsay, & Roux, 1997; Krassowski & Plante, 1997).

Behavior problems in children with SLI

The results of the study described in Chapter 5 show 40% of the children in the research group to produce a clinical (29%) or borderline (11%) total score on the Child Behavior Checklist (CBCL). This is in keeping with the outcomes of other studies of children with SLI including a recent Dutch study (Coster, 2001). Internalizing and externalizing behavior problems are reported equally often although a higher frequency of clinical as opposed to borderline scores is reported for internalizing behavior problems.

The internalizing behavior problems concerned primarily “withdrawn behavior” and “physical complaints.” The externalizing behavior problems concerned primarily “aggressive behavior” and “attention problems.” In addition, the scores on the scale for social problems from the CBCL were highly elevated. Problem behavior on the part of children with SLI can emerge as a result of frustration, rejection, teasing by peers, and/or insufficient self-confidence. When children with SLI are behaviorally withdrawn, this can result in fewer communication initiatives, which can then - in turn - constitute an additional threat to the children’s language development (e.g., Conti-Ramsden & Botting, 2004). Signs of anxiety were less striking in the research reported on here than in other studies (Jerome, Fujiki, Brinton & James, 2002). Clinical or borderline social problems or norm-violating behavior were also observed less often, possibly because of the age of the children studied, as shown in other studies (Brinton & Fujiki, 1999). Such problems may occur more frequently among older children due to fewer protective factors and/or increased self-reflection. The incidences of anxiety and norm-violating behavior can also increase with age. Problems with attention/concentration on the part of young children also merit attention as these were reported to occur for more than 10% of the children in the present research population with SLI.

Given the design and set-up of the present study, the possible relations between the different language factors identified in the factor analyses and the specific behavior problems reported for the children could be explored. The CBCL total-scores and the scores for internalizing behavior problems related most strongly to the language factors of phonology and lexical semantics. Externalizing behavior problems showed a weak relation to the language factor of phonology. The strongest relations for the three language factors and not, thus, the speech factor were found for social and attention problems. The fact that these two types of behavior problems and not, for instance, severe acting-out problems related most

strongly to the language problems of the children in the present research suggests that the behavior problems of young children with SLI may be less striking for parents or teachers and thus harbors the danger of the behavior problems of particularly children with SLI going largely undetected. This finding is completely in line with the results of a recent study by Conti-Ramsden et al. (2004). And the fact that problems with attention/concentration are so strongly related to language factors confirms the presupposition that such information-processing problems are an important factor in the language development problems of children with SLI (Hoffman et al., 2004; Tallal, 2000). Speech problems were completely or virtually unrelated to behavior problems in the present research, which is rather surprising in light of our previous acknowledgement that the speech factor appeared to be a stable factor for the five- and six-year olds studied here. That is, persistent speech problems can be expected to produce an increased degree of frustration on the part of children as they get older. Caution is again called for in the interpretation of these findings as the speech factor in our research involved a mix of different types of speech problems with reduced intelligibility as the shared feature. Some of the speech problems concerned oromuscular problems while others concerned planning problems. The various speech problems should probably be more clearly differentiated in future research in order to gain greater insight into the possible connections between the different types of speech problems and general or specific behavior problems on the part of children with SLI.

Specific Language Impairment revisited

For a long time, SLI was conceived of as a monolithic, homogeneous construct. The studies reported on here provide support for the recent insight that the language skills and thus the language delays of children with SLI are diverse and heterogeneous. The reported results show the language skills of young children with SLI to consist of four distinct but nevertheless connected language factors, namely, the lexical-semantic, syntax, phonology, and speech factors. The four factors could all be distinguished for the children at the ages of four, five, and six years, and the lexical-semantic and syntactic factors were also found to be very stable over time.

The language development of children with SLI does not proceed on its own but rather in a dynamic interaction with the social environment. When this interaction proves problematic, which the behavior study reported on here showed to frequently be the case for children with SLI, the danger of an extra threat to the already problematic language development of children with SLI presents itself (also see Way, 2007). Yet another developmental domain that appears to critically influence the language development of children with SLI is their cognitive development. The results of the present studies provide support for the view that the development of phonology, semantics, and syntax may be

connected to the quality of the child's cognitive development in general. The present results also provide support for the importance of auditory working memory for the development of children's language. Taken together, the present results show language development, also on the part of children with SLI, to be a heterogeneous and dynamic phenomenon in which various aspects of language and cognition cooperate.

Recent brain studies support this vision of SLI. The neuro-imaging study of Hagoort shows different areas of the brain to cooperate for language production (Hagoort, 2005). In the left temporal cortex, the memory processes in particular appear to occur and play an important role in the storage of the phonological characteristics of words, their syntactic characteristics, and the lexical specifications of words. Semantic information appears to be stored in many different areas of the brain but predominantly in the left middle and inferior temporal gyri. The different language processes (i.e., phonological, syntactic, and lexical) are thus localized in different subareas of the left inferior frontal gyrus (LIFG) while imaging studies show considerable overlap in the activation of the three subareas within the LIFG during language processing. Hagoort speaks, in this connection, of the unification of the parallel processes occurring on the semantic, syntactic, and phonological levels during language production. In addition to memory and unification, a control component that regulates attention processes is also active. This is important for conversational turn-taking behavior or the selection of the appropriate language when one can speak different languages. These processes appear to take place in predominantly the dorsolateral prefrontal cortex. The results of Hagoort's brain research thus suggest that one can speak of substantial overlap in the activation of different areas of the brain during the language production process, which also suggests "interactive concurrent processing in which various types of processing constraints are incorporated as soon as they become available." The findings of the behavior study reported on here are based upon only behavioral measures of language variables but nevertheless in keeping with the findings of the brain studies. In times of tremendous technical progress, further in-depth studies will presumably become possible in which neuro-imaging techniques can be used to better map the brain areas involved, their mutual connections, and their sequential or synchronic activation during the language processing of also children with SLI.

Some limitations on the present research

The empirical findings reported in this dissertation on the classification of the language of young children with SLI in the Netherlands are largely in keeping with the findings of recent linguistic and neuro-imaging studies of language development and promising for further, more in-depth study. There are, however, some limitations that should be mentioned on the present studies.

The longitudinal aspect of the study

The children in the studies reported on here were evaluated on three occasions, namely at the ages of four, five, and six years. To gain even greater insight into the development of language skills and other relevant factors, children should be studied across a wider age range in future research. Such study is also needed to gain more insight into the behavioral development of children with SLI and to possibly follow them into adulthood. There are indications, for example, that a fair number of children with SLI later suffer from psychiatric problems (Clegg, Hollis, Mawhood, & Rutter, 2005).

Domains of language associated with SLI

Children's pragmatic language development is a relatively new domain of study for children with SLI or autism (e.g., Bishop & Baird, 2001), but this domain of language was not specifically considered in the present research. The syntactic language factor as distinguished in the factor analyses concerned only the receptive syntactic skills of the children with SLI, evaluation of expressive syntactic skills is also of importance for classification purposes. Additional research is thus needed in which the syntactic language skills of children with SLI are studied using such methods as spontaneous speech analyses.

Information processing skills

The increased focus on the role of information processing problems in problematic language development was addressed in the present classification research via examination of the role of working memory. Auditory working memory in particular was found to play a role in various language skills. It has also been demonstrated that other aspects of children's information processing such as processing speed can play a role in SLI (Hayiou-Thomas, Bishop, & Plunkett, 2004). Such extended study, despite its importance, was nevertheless beyond the scope of the present studies.

Behavior problems

The fact that children with SLI can develop various behavior problems was confirmed by the findings here. This possibility was studied with the aid of the CBCL. Other sources of information regarding children's behavior, such as structured observations and psychiatric examination, should be used in future research to determine—for instance—the extent of overlap between SLI for at least some children and ADHD or autism (Cohen, Vallance, Barwick, Im, Menna, Horodezky, & Isaacson, 2000; Bartlett, Flax, Logue, Smith, Vieland, Tallal, & Brzustowicz, 2004).

Methods

The test battery used in the present research had the advantage of being composed of clearly valid assessment instruments, which made the detected classification structure reliable and replicable. With the aid of this instrumentation, theoretically valid language factors could be distinguished using factor analyses. The occurrence of a so-called

bootstrapping effect or the influence of the skills developed in one domain of language on the development of skills in other language domains could not be discerned. The within factor relations between different measurements were statistically too strong to leave space for other, between factor, relations. For the view that language development occurs on the basis of different but to a certain extent interdependent modules with a shared computational system such bootstrap effects are logical (Moyle, Weismer, Evans, & Lindstrom, 2007). More detailed research on the nature of these interrelations is therefore called for.

Given that the focus of the present studies was on the classification of the language development of young children with SLI, the relations between linguistic factors, information processing skills, and behavior problems were only examined in an exploratory manner. In light of current theoretical insights and the connections found in the present studies, further research should certainly be conducted on - for instance - the roles of working memory and withdrawn behavior in the language development problems of children using research methods specifically designed for this purpose.

In the present studies, a language control group was not used. A control group can nevertheless provide insight into the similarities and differences between normal versus problematic language development in relation to such questions as: Which domains of language develop earlier or later, at what tempo, and which interrelations emerge when? Such questions are of importance for understanding both children with normal language development and problematic language development but also for the formulation of theory and the drawing of clinical implications for diagnostic and treatment purposes.

Clinical implications

The results of the studies reported on in this dissertation revolve around four main themes: variation/heterogeneity, interrelations, cognition, and behavior. A number of recommendations can be made with respect to each of these themes and on the basis of the relevant findings.

Variation and classification

The results of the present research have implications for the assessment, diagnosis, and treatment of children with language development problems. With respect to the assessment of SLI in the Netherlands, it can be noted that classification in terms of the language factors identified in the present research has been adopted and is currently being used elsewhere in the Netherlands. A next step is to determine which specific methods can be used to map the language development of children with SLI within the domains of phonology, lexical-semantics, syntax, and speech in a reliable and replicable manner. The methods may include psychometric tests, linguistic analyses of spontaneous speech,

methodic observation of linguistic utterances, and/or questionnaires concerned with the linguistic utterances for both parents and teachers.

Language therapy

Adequate phonological information processing appears to be a prerequisite for the language development of young children. When the phonological skills of a child are found to be weak, treatment should be aimed at these skills. For very young children, however, this should probably occur via more indirect methods such as instructions to parents and teachers with respect to, for instance, speaking tempo and intonation. For older children, individual treatment may be undertaken with the aid of specially developed computer programs, for example. Theoretical insights may speak in favor of such treatment, moreover, but actual effect measurements for such interventions with either individual children or patient groups must clearly demonstrate facilitative effects.

The results of the present research confirm the view that phonological, lexical, and syntactic development go hand-in-hand for children with SLI. It is also highly probable that cognition and particularly the memory and planning/control aspects of children's information processing play a key role in their language development. In children with problematic or delayed language development, various linguistic and cognitive domains may thus function problematically and this may also vary from child to child. The treatment possibilities viewed from such a perspective may therefore require children with persistent problems to be initially treated using a broad spectrum of multidisciplinary interventions concerned with all aspects of language, memory and behavior. The progress of the child during the course of treatment should then be carefully monitored in order to determine the effectiveness of treatment and adjust the course of treatment as needed. The diagnostic picture of the child may thus change during the course of treatment, and diagnostic information should always constitute the starting point for treatment when viewed from such a dynamic perspective.

Cognition

In the studies described in this dissertation, two aspects of cognition were studied in relation to the different language factors identified for a population of children with SLI. The analyses first revealed a relation between nonverbal intelligence and three of the four language factors, and it is therefore argued that children with significant delays in their nonverbal development in combination with language development problems should be considered a specific group. The language delays of this group may be more severe but also more persistent than those of children with language problems having no delay in their nonverbal cognitive development and therefore make the elicitation of treatment effects also relatively slower. For diagnostic purposes, diminished nonverbal intelligence may be an indication for adjusted treatment expectations.

The cognition analyses also showed working memory capacity and, in particular, auditory working memory capacity to play a crucial role in the language development of children with SLI. Assessment of this aspect of children's cognitive abilities should also therefore, in light of the present results, constitute a standard part of the test battery administered to children with SLI prior to the start of treatment. Should screening indeed show the child's working memory to be weak, then specific training on this can be undertaken such as rhythm exercises or explicit instruction and training on specific storage strategies (Gathercole & Alloway, 2006). Compensation techniques, such as the multi-modal presentation of information, may also play an important role in supporting language acquisition in children with SLI.

Behavior

When a child with SLI also displays internalizing or externalizing behavior problems, this can impose an additional burden on the child's communicative interactions and thereby intensify his or her language problems. The assessment of children with SLI should therefore always include screening for any behavior problems. The administration of questionnaires to the parents and teachers of children with SLI for this purpose should be part of the standard test battery for such children. When behavior problems are reported by an informant, specific treatment objectives should be formulated in this domain as well. Individual training programs to improve the problem-solving capacities of such children when confronted with problematic social-communication situations can be considered (e.g., Brinton et al., 1998). Training programs for parents and teachers can also be considered to help them deal with the behavior problems of their children more adequately and thus successfully (e.g., Marton, Abramoff, & Rosenzweig, 2005). Finally, group training programs aimed at the improvement of social skills can also be offered (Webster-Stratton, Reid, & Hammond, 2001). It should be clear that for young children with severe and persistent SLI, the parents should receive intensive guidance with respect to their communicative interactions with the relevant child. Parental guidance in addition to speech and language therapy, linguistics, and neuropsychology should also therefore be a part of the multidisciplinary treatment of SLI in the future.

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Summary

In this dissertation, the results of a study of the classification of children with severe and specific language development problems, internationally referred to as *Specific Language Impairment (SLI)*, are described. The language development of 110 young children was followed longitudinally with the aid of the administration of a battery of tests composed in such a manner that various aspects of the children's language development were represented (i.e., phonology, lexicon, syntax). An inventory of various cognitive and behavioral aspects was also acquired via the administration of tests. On the first measurement occasion, the mean age of the children was 4.5 years. The children's language development was next assessed one and two years later. The children who participated in the study were enrolled — upon initial measurement — in special education for children with auditory and/or communicative limitations. Placement in such a school was based upon a delay of two standard deviations on speech and language tests and also a clear educational limitation due to communication problems. The children in the sample had no mental retardation (nonverbal IQ > 70), no peripheral hearing problems, no evidence of neurological problems, and no autism.

Considerable discussion of the inclusion criteria for a diagnosis of SLI has occurred during the past decade. Recent overviews have been based upon consensus among clinicians, but psychometric evidence has been lacking up until now. It was therefore attempted in the present study to attain such evidence. The results of the exploratory factor analyses described in Chapter 2 show four factors to distinguish themselves with respect to the language skills of the children studied: *auditory conceptualization, lexical-semantic knowledge, syntactic proficienc*y, and *speech production*. The four factors were validated by the clinical impressions of the children's teachers and speech therapists. And the four categories of language proficiency distinguished here strongly resemble recent clinical insights regarding the subtypes of SLI to be distinguished. However, the present data do not provide evidence for a distinct semantic-pragmatic language skill; determination of this specific skill may require test materials specifically developed for this purpose.

The results of the research described in Chapter 3 show the same four factors to be distinguished on the second and third measurement occasions spanning a period of one year. Three of the four factors proved very stable across this period while auditory conceptualization (i.e., phonology) proved somewhat less stable. The results of Structural Equation Modeling (SEM) showed the phonology language factor to be related to the lexical-semantic and syntax language factors and the lexical-semantics factor to be related, in turn, to the syntax and speech factors. This finding corresponds to recent neurobiological models of linguistic processing in which lexical and syntactic processes have been found to differ

and involve different but interdependent brain structures. In addition analyses showed nonverbal IQ to relate significantly to all of the language factors in the present study. With respect to auditory working memory, however, a differential relation was found: The strength of auditory working memory was a good predictor of syntactic language skills. It is thus possible that phonological processing disorders on the part of some children may house the danger of relatively more problematic and possibly chronic grammatical language problems.

The results of the research described in Chapter 4 were aimed at gaining a better understanding the role of working memory in the language processing of children with SLI. Three aspects of working memory were distinguished, namely: *phonological working memory, visual working memory, and central-executive working memory.* Via SEM, the possibility of capturing the relations between these different aspects of working memory and the four specific subtypes of language skill was explored. Phonological working memory showed a clear relation to the language factor of auditory conceptualization, which was strongly related in turn to syntactic skill. Visual working memory showed little or no relation to the different forms of language skill. And the significant correlation observed between central-executive working memory and the language factor of lexical-semantic knowledge may be due to the fact that word knowledge plays a role in both working memory tasks and lexical language tasks.

The research described in Chapter 5 was aimed at identification of the form and prevalence of behavior problems on the part of the children with SLI studied here. The results showed 40% of the children with SLI in the present study to have clinical (30%) or borderline (10%) total scores on the Child Behavior Checklist (CBCL). With respect to the CBCL syndrome scales, relatively high percentages were found for *withdrawn behavior*, *somatic complaints*, *thought problems*, *attention problems*, and *aggressive behavior*. Internalizing behavior problems and particularly *anxious* and/or *withdrawn behavior* were related to particularly the language factors of phonology and syntax. Externalizing behavior problems were particularly related to weak scores for the phonology language factor. Social problems related quite strongly to all of the language factors while concentration problems related to three of the language factors but not the speech production factor. The speech production factor did not relate to any of the behavioral problems.

The general conclusion to be drawn with respect to the classification of children with SLI is that empirical evidence has been provided for the viewpoint that different domains of language skill should be distinguished for children with SLI, namely: grammatical skills, lexical-semantic skills, speech production, and auditory-conceptualization/phonological skills. These underlying language domains could be distinguished for Dutch-speaking children with SLI at not only 4 years of age but also 5 and 6 years of age and appeared to be quite stable. Problems with the auditory working memory also appeared to relate to the language

development of the children studied here. Finally, the young children with SLI studied here showed considerable behavior problems, which may further limit their language development.

On the basis of the present results, it is recommended that clinicians arrange their practice for the diagnosis of children with SLI in such a manner that the children's capabilities in four distinct areas of language are adequately mapped. Assessment of the children's intellectual skills and the strength of their auditory working memory may also be useful. On the basis of these test findings, then, an individual profile containing the strong and weak points for each child can be attained and provide the starting point for the formulation of concrete treatment goals regarding language stimulation, the training of working memory and the modification of behavior problems.

Samenvatting

In dit proefschrift zijn de resultaten van een studie naar de classificatie van kinderen met ernstige en specifieke taalontwikkelingsproblemen, internationaal aangeduid als *Specific Language Impairment (SLI),* beschreven. Uitgaande van een longitudinaal design is de taalontwikkeling van 110 jonge kinderen onderzocht door middel van een batterij taaltests die zodanig was samengesteld dat uiteenlopende aspecten van taalvaardigheid (fonologie, lexicon, syntax) gerepresenteerd waren. Tevens werden door middel van testen enkele cognitieve aspecten en gedragsaspecten geïnventariseerd. Op het eerste meetmoment waren de kinderen gemiddeld 4.5 jaar oud. De taalontwikkeling van de kinderen werd na 1 jaar en na 2 jaar nogmaals onderzocht. De kinderen die aan het onderzoek deelnamen bezochten ten tijde van het eerste meetmoment het speciaal onderwijs dat zich richt op kinderen met auditieve en/of communicatieve beperkingen. Plaatsing op een dergelijke school vond plaats op basis van een achterstand van twee standaarddeviaties op spraak/taaltests alsmede een duidelijke onderwijskundige beperking vanwege de communicatieproblemen. De kinderen uit de steekproef hadden geen verstandelijke beperking (nonverbaal IQ > 70), geen perifere gehoorproblemen, geen evidente neurologische problemen en geen autisme.

De afgelopen decennia is er veel discussie geweest omtrent de inclusiecriteria met betrekking tot SLI. Recente overzichten baseren zich op consensus van klinici. Voor deze recente indeling ontbrak het echter tot op heden aan psychometrische evidentie. Getracht werd hierin door middel van huidig onderzoek te voorzien. De in Hoofdstuk 2 beschreven resultaten van exploratieve factoranalyses laten zien dat vier factoren met betrekking tot te onderscheiden taalvaardigheden bij de onderzochte kinderen gevonden werden: *auditory conceptualisation, lexical-semantic knowledge, syntactic proficiency and speech production.* Deze factoren werden gevalideerd met behulp van klinische indrukken van leerkrachten en logopedisten van de kinderen. De vier gevonden vormen van taalvaardigheid blijken sterk vergelijkbaar met recente inzichten met betrekking tot klinisch evident te onderscheiden subtypen van SLI. Onze data geven echter geen evidentie voor het bestaan van een specifieke semantisch-pragmatische taalvaardigheid. Voor het kunnen onderscheiden hiervan dient wellicht gebruik gemaakt te worden van specifiek daartoe geconstrueerd testmateriaal.

De resultaten van het in Hoofdstuk 3 beschreven onderzoek laten zien dat de vier factoren ook op het tweede en derde meetmoment, met een tussenliggende periode van 1 jaar, onderscheiden kunnen worden. Over deze periode waren drie van de vier factoren zeer stabiel, de factor auditieve conceptualisatie (phonology) iets minder. Verder toonde de SEM-analyse dat de taalfactor phonology gerelateerd was aan de taalfactoren lexical-semantics

en syntax, de taalfactor lexical-semantics op zijn beurt was gerelateerd aan syntax en speech. Deze bevinding is in overeenstemming met recente neurobiologische modellen betreffende linguïstiche porcessen, welke lexicale en syntactiche processen onderscheiden en laten zien dat er afzonderlijke, maar wederzijds afhankelijke hersenstructuren betrokken zijn. Verder toonden analyses aan dat het nonverbaal IQ enige samenhang vertoont met alle taalfactoren. Ten aanzien van het auditief werkgeheugen bleek er een differentiële relatie te bestaan: de sterkte van dit werkgeheugen bleek een goede voorspeller voor de syntactische taalvaardigheden. Mogelijk herbergen phonologische informatieverwekingsproblemen bij sommige kinderen het gevaar op relatief meer problematische, en mogelijk ook chronische, grammaticale taalproblemen.

Het onderzoek beschreven in hoofdstuk 4 richtte zich op de rol van het werkgeheugen bij kinderen met SLI. Er konden drie aspecten van het werkgeheugen onderscheiden worden, te weten *het fonologisch werkgeheugen, het visueel werkgeheugen en een centraal-executief werkgeheugen*. Via de SEM-methodiek werd vervolgens gezocht naar een model met betrekking tot de samenhang tussen deze aspecten van het werkgeheugen en de vier subtypen van taalvaardigheid. Het fonologisch werkgeheugen vertoonde een beduidende samenhang met de taalfactor auditieve conceptualisatie. Deze factor liet op zijn beurt een sterke samenhang met de syntactische vaardigheid zien. Er was nauwelijks significante samenhang tussen het visuele werkgeheugen met een van de vormen van taalvaardigheid. De samenhang van het centraal-executieve werkgeheugen met de taalfactor lexicaal-semantische kennis tenslotte, kan te maken hebben met het feit, dat bij zowel de werkgeheugentaken als de lexicale taaltaken, woordkennis een rol speelt.

Het onderzoek beschreven in Hoofdstuk 5 richtte zich op de vorm en prevalentie van gedragsproblemen bij de onderzochte kinderen met SLI. De resultaten lieten zien dat 40 % van de onderzochte kinderen met SLI een klinische (30 %), of borderline (10 %) totaalscore op de CBCL-gedragsvragenlijst heeft. Ten aanzien van de syndroomschalen werden er relatief hoge percentages gevonden ten aanzien van *'teruggetrokken gedrag', 'lichamelijke klachten', 'denkproblemen', 'aandachtsproblemen' en 'agressief gedrag'*. Internaliserende gedragsproblemen, met name angstig en/of teruggetrokken gedrag, waren met name gerelateerd aan de taalfactoren phonology en syntax. Externaliserende gedragsproblemen bleken met name gerelateerd aan zwakke scores op de factor phonology. Sociale problemen waren in behoorlijk sterke mate gerelateerd aan alle taalfactoren, concentratieproblemen bij drie taalfactoren en niet aan de factor spraak. De factor spraak bleek aan geen enkele vorm van gedragsproblematiek in opvallende mate gerelateerd.

Als algemene conclusie kan ten aanzien van de classificatie van kinderen met SLI gesteld worden, dat er empirische evidentie is geleverd voor de visie dat verschillende domeinen van taalvaardigheden bij kinderen met SLI onderscheiden kunnen worden, te

weten grammaticale vaardigheden, lexicaal-semantische vaardigheden, spraakproductie en auditieve (klank)conceptualisatie vaardigheden. Deze onderliggende taaldomeinen konden bij Nederlandstalige kinderen met SLI op zowel 4-jarige, als ook op 5-jarige en 6-jarige leeftijd worden onderscheiden en bleken over het algemeen zeer stabiel. Tevens lijkt de taalontwikkeling van de onderzochte kinderen gerelateerd aan problemen ten aanzien van het auditief werkgeheugen. Tenslotte bleken deze jonge kinderen met SLI aanzienlijke gedragsproblemen te hebben. Deze kunnen een extra beperkende rol hebben bij de ontwikkeling van hun taalvaardigheden.

Klinici in de praktijk wordt aanbevolen bij hun diagnostiek bij kinderen met SLI hun testmethoden zodanig in te richten, dat de vier te onderscheiden taalvaardigheden goed in kaart kunnen worden gebracht. Tevens lijkt het zinnig de intellectuele vaardigheden en de sterkte van het auditief werkgeheugen bij kinderen met SLI te inventariseren. Op basis van deze testbevindingen ontstaat per kind een individueel profiel van sterke en zwakke punten, van waaruit concrete behandelingsdoelen ten aanzien van de taalstimulering, training van mogelijk zwak auditief werkgeheugen, en ombuigen van eventuele gedragsproblemen, gesteld kunnen worden.

Curriculum Vitae

John van Daal werd op 2 januari 1958 geboren te Valkenswaard. Hij behaalde het VWO-diploma in 1976 en studeerde vervolgens ontwikkelingspsychologie aan de Universiteit te Nijmegen alwaar hij in 1983 afstudeerde. Zijn afstudeeronderzoek betrof de opzet van een communicatieprogramma voor een cliënt met autisme en zelfverwondend gedrag. Vanaf 1983 tot 1987 was hij werkzaam op ‘de Binckhof’ te Grave, een instelling voor zorg aan mensen met een verstandelijke beperking.

In 1991 behaalde hij zijn registratie tot klinisch psycholoog NIP welke met de komst van de BIG-wet omgezet werd in een BIG-registratie klinisch psycholoog. Vanuit dit kader participeert hij tot op heden in de opleidingen tot Gezondheidszorg-psycholoog en Klinisch Psycholoog.

Vanaf 1987 tot medio 2007 is hij werkzaam geweest op ‘Sint Marie’ te Eindhoven, een instelling voor diagnostiek en behandeling aan kinderen en jeugdigen met auditieve en/of communicatieve problematiek. Vanuit de functie Hoofd Diagnostiek leverde hij onder andere een bijdrage aan de ontwikkeling van multidisciplinaire diagnostiek ten aanzien van de doelgroep. Tevens stond hij op ‘Sint Marie’ mede aan de basis van de realisering van de zorg voor kinderen met stoornissen binnen het autistisch spectrum. Tenslotte was hij de eerste voorzitter van de Wetenschappelijke Commissie van ‘Sint Marie’. Vanuit die functie stimuleerde hij vele kennismanagement-projecten, zowel binnen ‘Sint Marie’ als daarbuiten. In dat kader werkte hij mee aan een project ter oprichting van een Landelijk Kenniscentrum Taalspraak.

Momenteel werkt hij als klinisch psycholoog/psychotherapeut binnen GGZ Noord & Midden Limburg te Venray, waar hij een bijdrage levert aan de hulpverlening aan adolescenten en aan volwassenen met autisme of ADHD.

Studies on Atypical Communication

Ludo Verhoeven & Hans van Balkom (Editors)

The aim of this series is to advance insight into the processes of communication within and across children and adults with special needs, including persons with learning disabilities, cognitive, physical and sensory impairments, and persons from culturally and linguistically diverse backgrounds. It combines interest in sociolinguistic and psycholinguistic accounts of the acquisition and transmission of language and communication in these populations, and in educational solutions to help individuals overcome or reduce communication disabilities and to support their participation in society.

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   Eliane Segers
2. Reading Comprehension in Deaf Children: The impact of the Mode of Acquisition of Word Meanings
   Loes Wauters
3. Language and Literacy Development in Children with Specific Language Impairment
   Marjolijn van Weerdenburg
4. Bilingual Children with Specific Language Impairment: Additionally Disadvantaged?
   Judith Steenge
5. Variation of Language, Cognition and Behavior in Children with Specific Language Impairment
   John van Daal