Language and executive functioning in children with ADHD

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Faculteit der Geesteswetenschappen

For Thomas

We made an agreement
from which millions of agreements grew

someone pointed at a stone and said stone
someone chopped down a tree and said wood

agreements soon covered the world
constantly branching and spreading
cocooning us in a world of agreements

someone pointed at the fire and said fire
someone roasted an animal and said meat

the agreements covered the world
branching and spreading, cocooning
us in a world of agreements

someone pointed at the stars and said
I will never leave you.

Excerpt from 'Agreement' by Thomas Möhlmann
Translation by David Colmer

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1

Introduction

People often have a fairly stereotypical view of children with attention-deficit/hyperactivity disorder (ADHD). This general impression is based on their behavioral symptoms. However, there is more to ADHD than these symptoms. In fact, there is some evidence from research that these children also have problems with language. These seem to occur in particular in the domain of pragmatics, linked to social aspects of language. For example, children with ADHD have difficulties with telling a story coherently, so that they introduce protagonists using only pronouns - assuming that the listener knows who they are talking about. There has been relatively little work done on the grammatical abilities of children with ADHD, but they do not seem to have major problems, in contrast to children with specific language impairment (SLI). There are very few studies that have compared the language problems of these two groups of children. Studies that have been done have also used rather general language instruments so that no detailed contrastive profile of the two clinical groups has emerged (Geurts 2008, Redmond 2004, 2005, 2011). It is the aim of this study to examine the language abilities of ADHD children in more detail and to compare them to SLI children.

Children with ADHD are known to have problems in executive functioning, an umbrella term for various higher order cognitive processes, responsible for goal-directed behavior. Previous research

has indicated that motor inhibition is most notably affected in these children (e.g. Pennington and Ozonoff 1996). In contrast, executive functioning in children with SLI has only recently become a topic of interest, although the diagnosis presupposes that there is no known aetiology for the language problems. Current research is, however, indicating that this group of children can have difficulties with executive functioning. It is not at all clear that such difficulties, if they exist, are responsible for their language problems. This study will examine executive functioning in both ADHD and SLI children to examine where possible overlap and differences lie.

As suggested above, it is possible that there is a link between executive functioning and language. This link has to date not been empirically demonstrated in typically developing children. Work on SLI children has concentrated more on empirically showing a relationship between the two areas rather than seeking an explanation for their language problems in executive dysfunctioning. On the other hand, Tannock and Schachar (1996) have proposed that both the behavioral and the pragmatic language problems of children with ADHD are caused by the same underlying deficits in executive functioning. This study will explore the relationship between language and executive functioning, both in children with ADHD and in children with SLI.

The research to be reported is based on both group comparisons and within-group or individual analyses. We will thus be able to make both quantitative and qualitative comparisons.

The organization of this thesis is as follows. Chapter 2 will provide a general introduction to ADHD and SLI, followed by an overview of previous research on language of children with these diagnoses. The overlap of these disorders will also be briefly discussed. The group with SLI will be presented first since they function as a benchmark for the ADHD group with respect to language.

Chapter 3 will start with a general introduction to executive functioning and then summarize work to date on this aspect of children with ADHD and children with SLI. Here, children with ADHD are discussed first, since their problems with executive functioning are more well-known. The relation between executive functioning and language will also be explored. The chapter concludes with the research questions and general hypotheses.

Chapter 4 will present the research method. Three groups of children will be studied: the SLI and ADHD groups will be compared to a typically developing group of the same age, that is 7- and 8-year-olds. The instruments and procedure used are described in detail as well as the statistical analyses.

The results are presented in Chapters 5, 6 and 7. Each of these chapters aims to answer one of the three research questions (also see Section 3.4). Chapter 5 presents the results on language, covering both pragmatic and grammatical abilities. Chapter 6 reports the results on executive functioning, more specifically inhibition, working memory, planning, cognitive flexibility and fluency. All are measured non-verbally. Chapter 7 then explores the relationship between the results related to language on the one hand and executive functioning on the other hand.

Finally, in Chapter 8, the findings of the study will be discussed and general conclusions will be drawn.

2

Language in children with SLI and ADHD

The main purpose of this chapter is to introduce the reader to SLI and ADHD, as these are the clinical groups of interest in the current study. The focus will be on their language problems. SLI will be discussed in Section 2.1 and ADHD will be discussed in Section 2.2. The reason for this order is that the secondary language problems of children with ADHD are more easily interpreted against the background of the primary language symptoms of children with SLI. The symptom overlap between ADHD and SLI will be discussed in Section 2.3. Section 2.4 will give an overview of the language domains affected in SLI and ADHD and will introduce the first of the three research questions of this study (see Section 3.4 for an overview).

2.1 SLI

2.1.1 General background

SLI is an acronym for specific language impairment. The term refers to the presence of language problems in the absence of other problems. By definition, there is no known cause for the language

problems in SLI[1]. Hence, SLI is also referred to as primary language impairment. This can be contrasted with secondary language impairment, where, at least hypothetically, other problems explain the presence of the language problems, for example in the case of Down's syndrome, autism spectrum disorders or, indeed, attention-deficit/hyperactivity disorders.

In order to diagnose SLI, the presence of language impairment needs to be established, preferably with standardized language tests. Omnibus tests that are used for this purpose normally include several language areas, such as phonology and morpho-syntax, tested both in comprehension and in production. According to Leonard (2000), a composite test score needs to be at least 1.25 SD below the mean. Apart from establishing the presence of language impairment, factors that could possibly cause the language impairment need to be excluded. Traditionally, several exclusion criteria are applied, such as problems with nonverbal intelligence, hearing, neurological functioning, oral structure/motor function and physical and social interaction (e.g. Stark and Tallal, 1981; Leonard, 2000).

Prevalence rates of SLI vary from 1% to 7%, depending on the exact criteria used for the diagnosis (Leonard, 2000). Furthermore, SLI occurs approximately three times more often in boys than in girls (Robinson, 1987). In a large-scale study in the U.S., Tomblin et al. (1997) estimated the prevalence of SLI in 5-year-olds at 7.4% (with 1.25 SD below the mean on an omnibus language test as the including criterion). An exact prevalence rate for the Netherlands is not available. However, there is no reason to think that it would be very different from the prevalence rates mentioned above.

---

[1] Genetic predisposition might play a role in all cases of SLI, but only so in combination with other, as yet underspecified, factors (see Leonard (2000) for an overview).

As Bishop (1997) describes, SLI is not a static disorder. There are children who are slow to pass through early language milestones, but then seem to catch up. In other children, there are persistent language problems, but the pattern of linguistic impairment can change over time. Treatment programs for SLI, usually conducted by speech/language therapists, vary widely, both in the procedures employed and in the areas of language receiving the greatest emphasis. With respect to the efficacy of treatment for SLI, Leonard concludes that:

'On the one hand, treatment seems to accelerate language learning in many children with SLI. On the other hand, for some children, this acceleration does not carry far enough to lead to normal language functioning. For such children, language problems, although mitigated, will remain as obstacles to social and academic success.' (Leonard, 2000: 209).

2.1.2 Language characteristics

Children with SLI have problems in language comprehension and language production, both of which will be described in this section. However, the focus will be on production. This is because the study described in this thesis also focuses on language production[2].

<u>Comprehension</u>

SLI children regularly have problems with language comprehension. Most often, these problems occur in combination with language production problems, as both types of problems are known to influence each other. An excellent overview of comprehension

[2] Most studies referred to were conducted in English-speaking countries. The fact that a study is conducted in English will not be mentioned separately when discussing the literature. However, it will be mentioned when a study is conducted in a language other than English. This is the case for this section as well as for the remainder of this thesis.

problems in SLI children can be found in Bishop (1997). She distinguishes between problems in speech perception and understanding word meaning, grammatical knowledge and discourse. The findings of her literature review will be briefly summarized below.

Speech perception involves two complementary skills; the ability to distinguish different sounds (discrimination), and the ability to treat allophones, i.e. sounds that are acoustically different, as equivalent (phoneme constancy). Children with SLI often have difficulties in discriminating brief or rapidly changing sounds. Moreover, problems with phoneme constancy are common too. In the latter case, SLI children seem to persist in immature perceptual strategies (Bishop, 1997).

Most SLI children are poor at learning new vocabulary. Vocabulary learning involves both phonological and conceptual abilities. There is little evidence for a deficit in the conceptual basis for language in children with SLI. Their problems with word learning seem to be related more closely to problems in setting up long-term phonological representations in the lexicon, a process hampered by poor phonological perception and/or memory (Bishop, 1997).

Children with SLI also have difficulties in understanding meaning distinctions that are signaled by syntactic relationships or grammatical inflections (Bishop, 1997). In other words, syntactic problems limit their ability to use syntactic knowledge to infer word meanings, i.e. to make use of 'syntactic bootstrapping' (Gleitman, 1990; Gleitman and Gleitman, 1992). Van der Lely (1994; 1996; 1997) and Van der Lely and Stollwerck (1996) have even argued that there is a homogeneous subtype of grammatical SLI, which is characterized by a so-called 'representational deficit for dependent relationships' in the computational syntactic system. This leads to inconsistency in forming or using syntactic structures that involve dependent relationships between syntactic elements. Therefore,

children with grammatical SLI would have to rely on other, non-syntactic cues to interpret meaning in sentences. This would lead to distinctive errors, for example in the interpretation of active and passive sentences, which cannot be attributed to immature language development. Other authors also report about selective impairment of one of the language domains, such as grammar, without a deficit in other language domains. (e.g. Friedman and Novogrodsky, 2008). However, Bishop et al. (2000) failed to find pure cases of grammatical SLI in a rather large sample. This raises questions about the extent to which one can generalize from cases with grammatical SLI to the SLI population as a whole.

Pragmatic comprehension or, in other words, understanding discourse by integrating language and context, is difficult for children with SLI (Bishop, 1997). More specifically, children with SLI are poor at drawing inferences. These inferences are needed to build a so-called mental model. Without a mental model of the meaning of what is said it is more difficult to retain information. Indeed, SLI children seem to have a poor memory for the literal as well as the inferred meaning of stories. However, in real life they often appear less impaired than their low scores on formal language tests imply, most likely because of their use of extralinguistic cues to infer the meaning of what is being said.

In sum, language comprehension is often impaired in children with SLI. This holds across all language domains. However, depending on the SLI subtype, problems are sometimes more evident in one domain than another.

<u>Production</u>

There is a longstanding debate in the literature about the nature of the language production problems in SLI. It could be the case that the language production of children with SLI is like those of typically

developing, but younger, children. On the other hand, it could also be the case that their language production is altogether different. The cover terms 'delay' and 'deviance' are often used to represent these dichotomous possibilities (Leonard, 2000). However, in his comprehensive overview of this topic, Leonard points out that this dichotomy does not adequately capture the various ways in which children with SLI may differ from typically developing children. Instead, profile differences seem to characterize the language of SLI children in a more appropriate manner. Profile differences occur when the relation between certain features of language does not match that seen in typically developing children. Leonard uses the example of SLI children functioning like typically developing children one year younger in their use of plural –*s*, but like typically developing children two or three years younger in their use of third singular –*s* verb inflection. So, a pattern of profile differences reflects a different degree of delay across features. Profile differences manifest themselves both at at micro level (within language domains) and at macro level (between language domains).

As was the case for language comprehension, language production of SLI children will be described for the domains of phonology, lexicon, (morpho-)syntax and pragmatics. Leonard (2000) and Schwartz (2009) provide more elaborate overviews.

Phonological problems are commonly seen in children with SLI. Usually, these problems do not exist in isolation from problems in other language domains. The general impression is that children with SLI show many of the phonological characteristics seen in younger typically developing children. Some areas, however, pose unusual difficulty (Leonard, 2000). It is clear from the literature that problems may arise not only in the phonological system itself, but also in the so-called phonology-motor conversion ability (i.e. in the process of physically making the sounds), leading to speech output disorders (Bishop, 1992). The status of these disorders is not clear.

Sometimes they are considered to be part of the symptomatology of SLI, sometimes they are referred to as a separate disorder, in particular developmental apraxia of speech (Maassen, 2004). A task depending heavily on various phonological abilities is the non-word repetition task. Not surprisingly, the non-word repetition task is difficult for children with SLI (e.g. Conti-Ramsden, 2001; De Bree, Rispens and Gerrits, 2007; Rispens and Parigger, 2010).

Children with SLI are late in acquiring first words, and slow in the subsequent acquisition of new words. (Leonard and Deevy, 2004). By the time SLI children enter the multi-word stage, their lexicon no longer matches the lexicon of typically developing younger children. In particular, verbs are difficult. The meaning of many verbs cannot be learned by a process of simply mapping the verb to an event. The sentence frames in which the verb appears also have to be learned. Only then, using syntactic bootstrapping (Gleitman, 1990; Gleitman and Gleitman, 1992), can the meaning of the verb be refined[3]. Unfortunately, the process of refining meanings based on sentence frames seems to be impaired in children with SLI (Leonard, 2000).

Morpho-syntactic problems are very common among children with SLI. Morpho-syntactic errors are also seen in typically developing younger children, but in children with SLI they persist and seem out of proportion in comparison to other linguistic problems. Bishop (2004) coined the term 'typical SLI', to refer to a distinctive subtype within the SLI group as a whole. This subtype is mainly defined by morpho-syntactic problems (such as immature sentence structure and omitted grammatical morphemes), although

[3] Syntactic bootstrapping can be opposed to semantic bootstrapping (Grimshaw, 1981; Pinker, 1984), where knowledge of semantics helps in acquiring syntax.

phonological difficulties (such as unintelligible speech) often are apparent as well[4].

Morpho-syntactic difficulties of SLI children come in two forms: difficulties with syntactic structure and difficulties with grammatical morphology. The two often are interrelated, but will be defined and described separately below.

Syntactic structure concerns the structural relationship between constituents in a sentence (Leonard, 2000). The first study in this area was executed by Menyuk (1964). She studied 3- to 5-year-old SLI children, and matched them to chronological age matched children. Her study focused on, for example, auxiliary inversion in questions, formation of the passive voice, and insertion of negative particles. Children with SLI deviated from the control group. Omissions were the most common type of deviation. An influential study by Morehead and Ingram (1973), using a language age matched control group, based on MLU[5], found that 5- to 8-year-old children with SLI did use major syntactic categories, but did not use them in as many different contexts as the controls. In other words, with respect to syntactic structure, they found more evidence for a delay than for deviance (these terms were elaborated upon at the beginning of this section). De Jong (1999) looked at argument structure in Dutch. The SLI children in his study, with a mean age of eight years, produced fewer verb arguments and used more intransitive verbs in comparison with a language age matched control group. Moreover,

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[4] Rapin and Allen (1987) therefore speak of the 'phonological-syntactic deficit syndrome'. However, because we do not know what would cause this syndrome, we prefer the term 'typical SLI'. Also, we will not use the term 'grammatical SLI' that Van der Lely (1987) uses. We feel that the grammatical problems of van der Lely's group are too specific and severe. Moreover, it has only been described in a relatively small group of English-speaking SLI children.

[5] Over the years, reflecting the relatively long SLI research tradition, the composition of the control groups changed. Control groups with children of the same mental age and/or children of the same linguistic age (usually matched on the basis of their mean length of utterance) are common practice nowadays, instead of just using a control group with children of the same chronological age. This obviously influenced the interpretation of the results.

verbs with more than one argument were used less frequently. They also sometimes made grammatical errors.

Grammatical morphology concerns the closed-class morphemes in a language (Leonard, 2000). SLI research has often focused on this language domain, more specifically on inflectional morphology and on function words such as articles and auxiliary verbs. Fletcher and Ingham (1995: 611) listed a number of problematical morpho-syntactic categories for English speaking SLI children: plural *–s*; third person *–s*; past tense *–ed*; auxiliary *be*; determiners *a/the*; infinitive particle *to* and case-marked pronouns. However, morpho-syntactic difficulties can be expressed differently and are apparent to a different degree in other languages. For Dutch, tense and agreement were studied by De Jong (1999). He compared his SLI group, with a mean age of eight years, with younger typically developing children and with chronologically age matched controls. The results showed that tense marking was more inconsistent in SLI children. In a past tense context they often omitted the tense marker or substituted a present tense marker. This was the case for both regular and irregular verbs. De Jong concluded that the inventory of past tense forms was immature in children with SLI, in that it resembled that of the younger control group. However, when it came to marking for the tense feature, the SLI children differed from both control groups. Errors were also found in subject-verb agreement. The SLI children made omission and substitution errors, and also sometimes used the infinitival form. According to De Jong, these errors typified the SLI group and were infrequent among children in the control groups.

Part of SLI research has focused on finding a so-called clinical marker for SLI. Given the children's obvious difficulties in that domain, this research was often directed at specific morpho-syntactic aspects of language. Conti-Ramsden, Botting and Faragher (2001)

compared four potential markers: third person singular marking, past tense marking, non-word repetition and sentence imitation. They measured these skills in 11-year-old SLI children. Sentence imitation proved to be the most successful task to identify children with SLI, with an overall accuracy of 88%. However, non-word repetition did quite well too, with an overall accuracy of 82%. Combining the two tasks (i.e. low performance on either of these tasks) resulted in an average of 89% accuracy.

According to Conti-Ramsden, Botting and Faragher (2001) the question is what the sentence imitation task and the non-word repetition task have in common. Clearly, both tasks involve memory. However, both tasks also contain linguistic components.

In the non-word repetition task, Gathercole and Baddeley (1990) argue that SLI children exhibit a deficit in the storage of phonological information in working memory. Because the acquisition of vocabulary depends on stable and distinct word representations, this would result in the SLI children's below-age vocabularies. Moreover, Gathercole and Baddeley (1993) argue that the deficits in phonological memory not only affect lexical learning, but also the comprehension of grammar, thus explaining SLI children's problems with complex sentences (as these are difficult to process on-line when memory fails).

The sentence imitation task seems to place more demands on prior language knowledge or the language knowledge base (Conti-Ramsden, 2001). Vinther (2002) adds that sentence repetition yields valuable data for evaluating the level of the subject's linguistic proficiency. This is because it can be deduced, from a more or less correct repetition, that the subject has processed the model and encoded it using the grammar available to him or her.

Pragmatic language problems in children with SLI are generally less severe than their morpho-syntactic and phonological problems, and

they are sometimes considered to be secondary to these problems. Leonard (2000) provided an overview of the narrative abilities in the SLI group as a whole. He concluded that SLI children in general do not manifest many problems organizing their stories. However, details that make for a complete, cohesive and engaging narrative are sometimes missing. These omissions can be related to syntactic and lexical problems, but may also indicate specific pragmatic problems.

However, others claim that, within the SLI group as a whole, a distinct subtype can be distinguished, consisting of children with pragmatic language impairment only (PLI; Bishop, 2004)[6]. The children's communication checklist, (CCC; Bishop, 1998; 2003) is often used to identify these children with PLI. It assesses a broad range of pragmatic abilities, not just narrative abilities (also see Section 4.3.3). So far, only a few studies have specifically and thoroughly investigated (semi-)spontaneous narratives of PLI children. Botting (2002) has found deficits in the organization of narrative content. PLI children included less information about the setting and ending of a narrative. Skills related to the linguistic structure seemed relatively intact. Ketelaars (2010) stated that Dutch PLI children were also impaired in story content organization. Moreover, narrative productivity was impaired; the stories were shorter and had a reduced syntactic complexity.

In sum, all productive language domains are affected in children with typical SLI, but some more so than others. Generally speaking, lexical and pragmatic skills are less impaired than grammatical morphology. Argument structure and phonology fall somewhere in between (Leonard, 2000).

[6] The language problems in PLI show a considerable overlap with the language problems in children with autism spectrum disorders (ASD).

In Section 2.2, we will discuss the background and language characteristics of ADHD children. SLI children's language profile will serve as a benchmark against which to compare the language profile of children with ADHD.

2.2 ADHD

2.2.1 General background

ADHD is an acronym for attention-deficit/hyperactivity disorder. The diagnosis is normally based on the definition in the diagnostic statistical manual of mental disorders (DSM). This manual is used by clinicians and psychiatrists. At the time of the data collection for this study, the most recent version was the DSM-IV-TR (American Psychiatric Association, 1994; 2001). It distinguishes two clusters of symptoms: (1) symptoms of inattention and (2) symptoms of hyperactivity-impulsivity. Each symptom-cluster consists of nine symptoms. An overview of all ADHD symptoms is presented in Table 2-1.

DSM-IV-TR symptoms of ADHD

I. Either A or B:

A. Six or more of the following symptoms of inattention have been present for at least 6 months to a point that is disruptive and inappropriate for developmental level:

Inattention

1. Often does not give close attention to details or makes careless mistakes in schoolwork, work, or other activities.
2. Often has trouble keeping attention on tasks or play activities.
3. Often does not seem to listen when spoken to directly.
4. Often does not follow instructions and fails to finish schoolwork, chores, or duties in the workplace (not due to oppositional behavior or failure to understand instructions).
5. Often has trouble organizing activities.

6. Often avoids, dislikes, or doesn't want to do things that take a lot of mental effort for a long period of time (such as schoolwork or homework).
7. Often loses things needed for tasks and activities (e.g. toys, school assignments, pencils, books, or tools).
8. Is often easily distracted.
9. Is often forgetful in daily activities.

B. Six or more of the following symptoms of hyperactivity-impulsivity have been present for at least 6 months to an extent that is disruptive and inappropriate for developmental level:

Hyperactivity

1. Often fidgets with hands or feet or squirms in seat.
2. Often gets up from seat when remaining in seat is expected.
3. Often runs about or climbs when and where it is not appropriate (adolescents or adults may feel very restless).
4. Often has trouble playing or enjoying leisure activities quietly.
5. Is often "on the go" or often acts as if "driven by a motor".
6. Often talks excessively.

Impulsivity

7. Often blurts out answers before questions have been finished.
8. Often has trouble waiting one's turn.
9. Often interrupts or intrudes on others (e.g., butts into conversations or games).

Table 2-1: overview of DSM-IV-TR symptoms of ADHD

An ADHD diagnosis can be given when six or more of the symptoms from either cluster A or cluster B have been present for at least six months. Some of the symptoms must have been apparent before the age of seven. In addition, the symptoms have to cause significant impairment in everyday functioning and have to appear in at least two different environments (for example home and school). It also has to be clear that the symptoms cannot be ascribed to another disorder (see Table 2-2 for an overview).

Three different ADHD subtypes are distinguished in the DSM-IV-TR: (1) ADHD, combined type; (2) ADHD, mainly hyperactive-impulsive type, and (3) ADHD, mainly inattentive type. To qualify for

the first subtype, six or more symptoms from each of the clusters have to be present; for the other two subtypes six or more symptoms from either cluster are sufficient.

DSM-IV-TR criteria of ADHD
1. Either A or B (see Table 2-1).
2. Some symptoms that cause impairment were present before age 7 years.
3. Some impairment from the symptoms is present in two or more settings (e.g. at school/work and at home).
4. There must be clear evidence of significant impairment in social, school, or work functioning.
5. The symptoms do not happen only during the course of a Pervasive Developmental Disorder, Schizophrenia, or other Psychotic Disorder. The symptoms are not better accounted for by another mental disorder (e.g. Mood Disorder, Anxiety Disorder, Dissociative Disorder, or a Personality Disorder).

Table 2-2: overview of DSM-IV-TR criteria of ADHD

In the Netherlands, ADHD occurs in 2% to 6% of schoolchildren, four times more often in boys than in girls. The syndrome persists into adulthood in about 33% of the children, resulting in a lower prevalence rate in adults (Gezondheidsraad, 2000). Co-morbidity, especially with other externalizing disorders, such as oppositional defiant disorder (ODD) and conduct disorder (CD) is often present in ADHD (Angold, Costello and Erkanli, 1999). ADHD has a strong impact on everyday functioning. For example, underachievement in school is quite common, and is associated with symptom severity (DeShazo Barry, Lyman and Grofer Klinger, 2002). ADHD symptoms are normally treated with medication and/or psychosocial therapy. Medication to treat ADHD symptoms usually contains methylphenidate, an amphetamine-like substance. This kind of medication is helpful in approximately 80% of the children (Gezondheidsraad, 2000). Van der Oord, Prins, Oosterlaan and Emmelkamp (2008) performed a meta-analysis and compared various forms of treatment for 6- to 12-year-old ADHD children. They concluded that methylphenidate, psychosocial treatment and a

combination of the two therapies are effective, but that psychosocial treatment on its own yielded lower effect sizes.

2.2.2 *Language characteristics*

Table 2-1 shows that the ADHD symptom list also includes symptoms that seem to be indicative of language problems, at least in the pragmatic domain, such as *often does not seem to listen when spoken to directly* (inattention), *often talks excessively* (hyperactivity) and *often blurts out answers before questions have been finished* (impulsivity)[7].

The overlap between ADHD and language problems is regularly mentioned in the literature. For example, Cohen (1998) found that in 7- to 14-year-old children, presenting as child psychiatric outpatients and meeting the criteria for language impairment, 46% have a diagnosis of ADHD. This percentage can also turn out to be higher, especially when language is examined in more detail. For example, a Dutch study among psychiatrically impaired children, including ADHD children, found that the vast majority of these children have some kind of problem with morpho-syntactic and/or pragmatic aspects of language (Blankenstijn and Scheper, 2003).

However, the precise nature and extent of language problems in ADHD children have not been the focus of much research. Literature about language problems and possible language impairment in children with ADHD will be reviewed and summarized in this section (with one exception: research aimed specifically at comparing ADHD children's language to SLI children's language will be discussed in Section 2.4). As in the previous section on SLI, the review reports on phonology, lexicon, (morpho-)syntax, and pragmatics, both in language comprehension and in language production - and the focus will again be on the latter.

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[7] Parts of Section 2.2.2 were published earlier, in Dutch. See, for example, Parigger and Baker (2005).

It is important to note that research on ADHD language is of two types: research focusing on the ADHD group as a whole, and research directed at either of two ADHD groups, one with, and one without language problems (LP) and/or reading problems (RP). These groups are usually created with the help of standardized language tests, but they do not resemble the typical SLI group because the exclusion criteria are not applied (see Section 2.1.2). Moreover, these groups have nothing to do with the three ADHD sub-groups mentioned in the DSM-IV-TR. However, the ADHD children in language research are often only taken from the hyperactive and combined subtypes. This is because there is reason to believe that the ADHD inattentive subtype behaves differently (Milich, Balentine and Lynam, 2001).

It is also the case that the comparison groups in SLI and ADHD language research differ. Whereas SLI children are often matched to children that have the same linguistic and/or mental age, ADHD children are normally matched to children that have the same chronological age. This difference reflects the state-of-the-art in the two areas; on the basis of previous research, SLI researchers are able to ask more specific questions about the nature and extent of the language problems. This is not (yet) the case for ADHD researchers, who are still establishing the mere existence of language problems.

<u>Comprehension</u>

Speech perception depends on the ability to discriminate different sounds and on the ability to treat sounds that are acoustically different as equivalent (Bishop, 1997: also see Section 2.1.2). Norrelgen, Lacerda and Forssberg (1999) showed that speech discrimination is not impaired in children with ADHD (8-15 years of age). This was only the case as long as phonological working memory was not involved in the speech discrimination task. Furthermore, studies trying to disentangle ADHD and reading

problems (RP) showed that problems in speech discrimination are more closely linked to RP than to ADHD (e.g. Breier, Gray, Fletcher, Foorman and Klaas, 2002; also see Section 2.3 for the co-morbidity between ADHD and RP). Studies on phoneme constancy in children with ADHD were not found.

Only a few studies have looked at the understanding of word meaning in children with ADHD. Kim and Kaiser (2000) found that 27% of the children with ADHD (6-8 years of age) had below-average scores on a receptive vocabulary test. Another study, by Velgersdijk (2001), found that two out of five Dutch ADHD children (7 years of age) scored below the mean on a test for semantic language comprehension. However, neither study established a significant group difference with typically developing children. Purvis and Tannock (1997) compared children with ADHD, children with ADHD and RP, children with RP-only and typically developing children (7-11 years of age). Deficits in receptive semantic abilities were only found in children with RP, regardless of their ADHD status.

Only one study (Velgersdijk, 2001) has looked at the comprehension of (morpho-)syntax in Dutch ADHD children and typically developing children (7 years of age). This was measured with a standardized test. No group differences were found.

Velgersdijk (2001) did, however, find that four out of five Dutch ADHD children (7 years of age) performed below the mean of a norm group on a test for pragmatic language comprehension, although, again, she did not detect significant differences when these children, as a group, were compared to a group of typically developing children. Other studies in the pragmatic language domain focused on the comprehension of narratives. Tannock, Purvis and Schachar (1993) offered two audio-taped stories to the children in their study, and asked them to retell these stories. Children with ADHD (7-11 years of age) were as skilled as the control children in comprehending and extracting the main ideas from the

stories. Lorch et al. (1999; 2000; 2004) investigated the comprehension of videotaped stories. The ADHD children (7-12 years of age) reached the same score on a structured series of questions about the story as the control children. However, they had significantly more difficulties interpreting the causal structure of the stories. This was only the case when, while they were watching the stories, toys were also present in the room. So, not surprisingly, the problems with this kind of language comprehension could be related to visual attention. McInnes, Humphries, Hogg-Johnson and Tannock (2003) presented four audiotaped texts to the children in their study, followed by factual and inferential questions about these texts. The ADHD+LP group (9-12 years of age) and the group with language impairment-only had significantly lower scores than the ADHD-LP group and the typically developing control children. The authors also presented the children with a narrative comprehension test. The children with language impairment-only had the lowest scores on this test. The two ADHD groups had significantly higher scores and did not differ from the control group.

In sum, although the evidence available is too limited to draw firm conclusions, phonological, lexical and (morpho-)syntactic comprehension do not seem to be impaired in children with ADHD. However, it is possible that ADHD children experience mild problems in pragmatic language comprehension.

Production

Some ADHD research on language has focused on the amount of language produced. These quantitative measures are often compared across different situations. This is because each situation places its own cognitive and linguistic demands, often influencing the outcomes of the quantitative language measures. Barkley, Cunningham and Karlsson (1983) found that hyperactive children (9-

10 years of age) and their mothers produced more utterances than control children and their mothers. These differences were only apparent in a free play situation and not in a task situation. Subsequent research showed that the use of medication in the hyperactive children reduced the number of utterances of these children, which in turn reduced the total amount of utterances of their mothers. The study by Zentall et al. (1988) also found that hyperactive children (9 years of age) used more words and utterances than control children. This was the case only during transitions and non-verbal tasks (non-elicited conditions). They were less talkative when they were asked to tell stories (elicited conditions). In particular, stories requiring organization and planning without external structure or visual cues produced production deficiencies.

Children with ADHD do sometimes experience speech output problems. However, they do not occur as often as language production problems, and normally occur together with language production problems (see Tannock and Schachar, 1996). Moreover, speech output problems seem to decrease with age (e.g. Baker and Cantwell, 1992). Javorsky (1996) used several standardized measures of phonology. Children with ADHD+LP (6-17 years of age) had significantly lower scores than children with ADHD-LP. Moreover, children with ADHD+LP did not differ from the language impairment-only group. Purvis and Tannock (2000) investigated phonological processing. They found, as other studies did, that problems associated with phonological processing are more closely related to reading problems than to ADHD.

ADHD children are sometimes claimed to be delayed in the onset of their first words and word combinations, although the evidence for the delay is not consistent (see Tannock and Schachar, 1996). ADHD children do not seem to experience semantic problems as measured with standardized tests (e.g. Javorsky, 1996; Purvis and

Tannock, 1997; Kim and Kaiser, 2000). However, Tannock, Martinussen and Frijters (2000) did find evidence for deficits in naming speed associated with effortful semantic processing. Children with ADHD, both with and without concomitant reading problems (7-12 years of age), were significantly slower on a color-naming task. Medication improved, but did not normalize, their scores.

The study by Van Lambalgen, Van Kruistum and Parigger (2008) focused on (morpho-)syntax in Dutch ADHD children (7-9 years old). The main hypothesis was that children with ADHD use strategies for discourse production, which reduce the burden for themselves, but increase it for the hearer. Several language areas where such strategies might be at work were identified. In the tense domain, several differences were found that were near significant. Combined in a general complexity-reducing strategy (avoiding perfect tenses, avoiding tensed verbs, preference for direct speech), the difference with the typically developing children was significant. Geurts (2004a) assessed syntax with the syntax scale of the children's communication checklist (CCC - see Section 4.3.3). Children with ADHD (5-14 years of age) did not appear to experience more syntactic problems than typically developing control children. However, Zentall, et al. (1983) did a qualitative study and found that children with ADHD (6 years of age) produced significantly more dysfluencies in conversations. More specifically, they used more starters and fillers, revised and repeated what they said and completed fewer statements than controls. Javorsky (1996), using various standardized syntax measures, found that the syntactic level of children with ADHD+LP (6-17 years of age) did not differ from that of children with language impairment-only, and was lower than that of children with ADHD-LP. Finally, Oram, Fine, Okamoto and Tannock (1999) focused on sentence imitation. This task is partly dependent on syntactic abilities (see Section 2.1.2). They found that

ADHD-LP children (7-11 years of age) performed worse than typically developing children. Other studies also report ADHD children's problems with the sentence imitation task (e.g. Kim and Kaiser, 2000; Redmond, 2004)[8].

Pragmatic abilities in children with ADHD have been studied more extensively than abilities in the other language domains. Kim and Kaiser (2000) found that 27% of the ADHD children (6-8 years of age) scored poorly on a pragmatic language test, although the scores of the ADHD group as a whole did not differ significantly from the scores of the control group. As has been said, Geurts et al. (2004a) made use of the children's communication checklist. Children with ADHD (5-14 years of age) were found to have significantly lower scores than control children, particularly in pragmatic aspects of language. Their stories were, for example, less coherent. Moreover, they conversed in a more stereotyped way and made less use of the context of the conversation. Geurts (2008) also found that children with ADHD (7-14 years of age) had pragmatic problems. She compared the ADHD children to children with autism spectrum disorder. On most subscales of the children's communication checklist, the groups could not be differentiated from each other, but often the raw scores of the ADHD children were in between those of the children with autism spectrum disorder and the typically developing children. Cohen, et al. (2000) compared ADHD+LP to ADHD-LP children (7-14 years of age). Although they did not include a typically developing comparison group, they did include two groups with other psychiatric problems, one with, and one without additional language problems. The groups with language problems performed worse on the pragmatic measures than the groups without language problems. In conversation with an

[8] As was mentioned before, research comparing ADHD and SLI children's language is discussed in Section 2.4. The studies by Redmond (2004, 2005, 2011), which will be discussed in that section, make use of morphological measures, as well as more syntactic measures.

adult partner, Kim and Kaiser (2000) found that children with ADHD (6-8 years of age) produced more pragmatically incorrect utterances than control children. The five most common errors were: not answering questions or requests, interrupting others, failing to give feedback to the conversation partner, making use of non-specific vocabulary (i.e. overuse of unspecified referents that results in ambiguity of the message; also includes inappropriate choice of lexical items) and producing utterances which lacked cohesion. In the study by Tannock et al. (1993), children had to retell stories after listening to an audiotape. ADHD children (7-11 years of age) produced fewer plot components than control children. Moreover, they sometimes made errors when ordering the plot components. The study also showed that these children made more misinterpretations, inaccurate substitutions and ambiguous references. Renz et al. (2003) also asked children to retell a story, in this case on the basis of unfamiliar pictures (the frog story; see Section 4.3.1). After doing so, the children had to retell the story a second time. They found that children with ADHD (9-11 years of age) indeed differed from control children in the way they structured the story. For example, they mentioned the attainment of the overall goal of the story less often. Moreover, the coherence of the narratives of the children with ADHD was marred by a higher rate of errors (for example reference errors and unclear or ambiguous utterances). The ADHD children were also were less likely to adjust their story on the basis of the information acquired during the first narration. Purvis and Tannock (1997) compared the narrative abilities of children with ADHD with or without concomitant reading problems (7-11 years of age). They found that children with ADHD, irrespective of their reading status, had problems organizing and monitoring their stories.

The language problems described in this section are apparent when comparing the ADHD group as a whole on the one hand, and the ADHD-LP group on the other hand, to a group of typically developing children. The nature and extent of these language problems go beyond the language symptoms listed in the DSM-IV-TR diagnosis (described in Section 2.2.1 and at the beginning of Section 2.2.2). Not surprisingly, the literature also describes language differences between ADHD+LP children and ADHD-LP children.

ADHD children produce more words and phrases than typically developing children in situations where language is not elicited. However, in situations where language is elicited, and where additional structuring is not provided, they produce fewer words and phrases. ADHD children usually do not differ from typically developing children on standardized language tests for phonology, semantics and (morpho-)syntax. However, differences are found when evaluating specific areas within these language domains with specific tasks. This is especially the case for articulation (phonology), color naming (semantics), and sentence imitation (syntax). The most problematic language domain for children with ADHD is pragmatics. ADHD children consistently perform less well than typically developing children on pragmatic language questionnaires. The pragmatic difficulties of children with ADHD are also evident in analyses of conversations and narratives.

This summary gives an indication of the language problems found in ADHD children. However, the studies reviewed all suffer from methodological constraints, albeit to varying degrees, for example inaccurate ADHD diagnoses, co-morbidity or lack of detail on medication, small research groups, inadequate statistics etc. Hence, the results should be interpreted with caution.

2.3 Association between SLI and ADHD

Strictly speaking, co-morbidity between ADHD and SLI cannot occur, because the presence of ADHD is considered an exclusion criterion for the SLI diagnosis. Therefore, we will speak of 'association between ADHD and (S)LI' instead of 'co-morbidity' (also see Wittchen, 1996 for a critical discussion about the concept of co-morbidity).

According to Tannock and Schachar (1996) the association between ADHD and (S)LI is greater than could be expected on the basis of chance, given the base rate of each disorder in the community. The expected association would then be 1.7%. This is substantially lower than, for example, the observed association of 30% in the epidemiological study by Beitchman, Hood, Rochon and Peterson (1989). Estimates of the overlap in clinically referred samples vary widely. However, systematic assessment of current language abilities using standardized tests indicates that 15% to 76% of the children with ADHD exhibit language impairments. On the other hand, 20% to 60% of the children with language impairments present with ADHD. The variation is largely attributable to differences in how ADHD and language impairments were defined in the studies (see for a review Tannock and Schachar, 1996: 133-136).

A related issue is the presence of reading problems in SLI on the one hand and ADHD on the other hand. Reading problems frequently occur, both in SLI (e.g. Stark, Bernstein, Condino, Bender, Tallal and Catts, 1984; Silva, Williams and McGee, 1987; Flax, Realpe-Bonilla, Hirsch, Brzustowicz, Bartlett and Tallal, 2003) and in ADHD (e.g. Purvis and Tannock, 2000; Tannock, Martinussen and Frijters, 2000). The three circles in the diagram in Figure 2-1 represent three groups of children: one with symptoms of inattention and hyperactivity-impulsivity, one with language problems, and one with reading problems. However, the four places

of overlap of these circles represent children with a combination of symptoms.

The focus in this thesis is on ADHD and language. However, problems with reading will also be taken into consideration. We will come back to reading problems, and to this diagram in Sections 5.7.2 and 8.3.

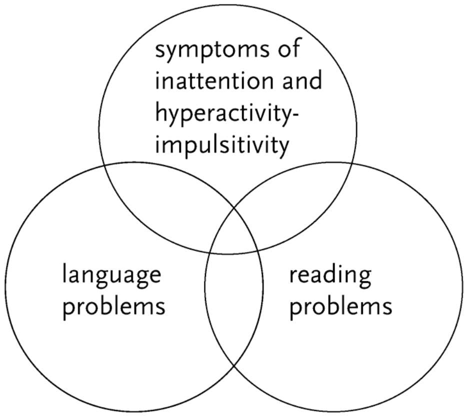

Figure 2-1: Venn diagram of overlap between symptoms of inattention/ hyper-activity-impulsivity, language problems and reading problems

2.4 Overview of affected language domains in SLI and ADHD

As was discussed before, for example in Section 2.1.2, SLI children's language profile will, in this study, serve as a benchmark against which to compare the language profile of children with ADHD. Therefore, three additional studies need to be discussed in which the language characteristics of SLI children were directly compared to the language characteristics of ADHD children (and were therefore not included in either Section 2.1.2 or Section 2.2.2).

Redmond (2004) compared the conversational profiles of children with ADHD, children with SLI and typically developing children (5-8 years of age). The conversational samples were

collected during free-play with an examiner. Utterance formulation measures (percent words mazed; average number of words per maze[9]) differentiated the ADHD group from the SLI and TD groups (ADHD>SLI=TD). In contrast, measures of lexical diversity (number of different words in 100 utterances), average sentence length (mean length of utterance) and morpho-syntactic development (composite tense) differentiated the SLI group from the ADHD and TD groups (SLI<ADHD=TD). Redmond (2005) also administered measures of sentence imitation and past tense elicitation to these children. Compared to the typically developing children, sentence imitation was difficult for both clinical groups, but more so for SLI children than for ADHD children (SLI<ADHD<TD). However, limitations in past tense marking were characteristic of the SLI group only (SLI<ADHD=TD). In another study, Redmond (2011) tested the capacity of different language indices to successfully discriminate SLI children from children with ADHD and typically developing children (7-8 years of age). The ADHD group in this study consisted of children who scored within the normal range of a reference measure for language impairment. Redmond focused on tense marking (regular third person present tense and past-tense probes from the test of early grammatical impairment (TEGI: Rice and Wexler, 2001), non-word repetition (task by Dollaghan and Campbell, 1998), sentence recall (task by Redmond, 2005) and narratives (test of narrative language; Gilliam and Pearson, 2004). Significant group differences were observed on all four measures and each measure demonstrated the same pattern of results: SLI<ADHD=TD. Diagnostic accuracy was high for all four psycholinguistic measures, although it was relatively harder to discriminate SLI from ADHD than that it was to discriminate SLI from TD.

[9] A maze refers to any false start, repetition, or reformulation. When maze words are removed from the utterance, the remaining words can stand by themselves (definition taken from SALT (Miller and Chapman, 2000)).

Table 2-3 gives an overview of the affected language areas in children with SLI and in children with ADHD. The table clearly shows that SLI children encounter problems in all language domains, albeit in varying degrees. The problems in productive (morpho-)syntax are most noticeable. In the case of ADHD however, the picture is less clear, although it is obvious that children with ADHD experience pragmatic language production problems.

Language	**SLI**	**ADHD**
Comprehension		
Phonology	+	-
Lexicon	+	-
Morpho-syntax	+	-
Pragmatics	+	+/- (i.e. inferential questions)
Production		
Phonology	+	+/- (i.e. articulation)
Lexicon	+	+/- (i.e delayed onset)
Morpho-syntax	++	+/- (i.e. sentence imitation/mazes)
Pragmatics	+	+

Table 2-3: affected language domains in ADHD and SLI. ++ = salient problems; + = problems; +/- = problems possible; - = no problems

In this thesis, we will establish the similarities and differences in language of children with ADHD compared to children with SLI and typically developing children. This is formulated in the first of the three research questions in this study[10]:

Do children with ADHD differ in language production in comparison with typically developing children and do they differ from SLI children?

[10] The other two research questions will be formulated in Sections 3.2.2 and 3.3.

The focus in this study will be on pragmatics and morpho-syntax in production. This decision is based on the literature reviewed in this chapter, showing that pragmatics and morpho-syntax are the most problematic language domains in ADHD and SLI children respectively (see Table 2-3)[11]. General expectations about the three research questions will be presented in Section 3.4.

[11] These language domains also interact with each other, particularly in the area of reference, although the nature of this interaction is rather unclear (e.g. Rozendaal, 2008). The interaction between the two language domains will not be studied in this thesis.

3

Executive functioning and language

Most of the studies on language problems of children with ADHD are descriptive in nature (see Section 2.2.2). That is, the language problems go unexplained. As mentioned in Chapter 1, the exception is the work by Tannock and Schachar (1996). They go beyond a pure description of ADHD children's language and theorize that:

'*(...) executive dysfunction may account for both the core behavioural problems and the pragmatic disorders commonly observed in ADHD*' (Tannock and Schachar 1996: 145).

In other words, Tannock and Schachar propose that linguistic symptoms of ADHD are caused by non-linguistic factors. In the literature, executive dysfunctioning is often linked to the behavioral symptoms of ADHD (e.g. Pennington and Ozonoff, 1996), but not specifically to the pragmatic language symptoms.

First of all, executive functioning will be introduced in Section 3.1. Section 3.2 will discuss executive functioning in abnormal development, in particular in children with ADHD and in children with SLI. Section 3.3 will focus on the relation between executive functioning and language (more specifically: on pragmatic aspects

of language). Finally, Section 3.4 will recap the two research questions from Sections 2.4 and 3.3, and will also introduce the third research question. Moreover, the general expectations for all three questions will be provided.

3.1 Introduction to executive functioning

Executive functioning is an umbrella term, encompassing several interrelated higher order cognitive processes. Together, executive functions enable self-control and are responsible for:

'*(...) the ability to maintain an appropriate problem solving set for attainment of a future goal.*' (Welsh and Pennington, 1988: 201).

Executive functions are needed for many everyday activities, especially non-routinized situations, such as organizing a family activity, meeting a friend downtown, doing the groceries etcetera (Huizinga, 2006: 87-124). In general, multiple steps with intermediate results are involved in such situations. Moreover, adequate responses to these steps and results are necessary (Shah and Miyake, 1999). There is considerable debate as to how many executive functions can be distinguished. Traditionally, Pennington and Ozonoff (1996) discriminate between five executive functions: inhibition, working memory, planning, cognitive flexibility and non-verbal fluency. In this thesis, we will use measures based on this taxonomy, which can be applied to study normal and abnormal development in executive functioning (Geurts, 2003: 163-174)

Executive functions are strongly associated with the prefrontal cortices of the brain, and their neural networks (Pennington and Ozonoff, 1996). Different regions within the prefrontal cortices underlie different components of executive functioning (e.g. Aron, Robbins and Poldrack, 2004; Narayanan, Prabhakaran, Bunge,

Cristoff, Fine and Gabrieli, 2005; Crone, Wendelken, Donohue and Bunge, 2006). The prefrontal cortices develop during childhood, adolescence and young adulthood (e.g. Casey, Tottenham, Liston and Durston, 2005; Amso and Casey, 2006). Thus, executive functions develop simultaneously with the prefrontal cortices, and, as a consequence, executive functioning becomes more efficient as children grow older. Moreover, executive functions do not develop at the same rate; mature levels of performance on different executive functioning tasks are reached at different ages (Diamond, 2002; Welsh, 2002). Huizinga, Dolan and Van der Molen (2006) studied Dutch children's executive functioning (7, 11, 15 and 21 years old). They also found evidence for different developmental trajectories of several executive functions. For example, the development of shifting continued into adolescence, i.e. 15 years of age, and working memory continued to develop into young adulthood, i.e. 21 years of age.

3.2 Executive functioning in children with ADHD and SLI

This section will discuss non-verbal executive functioning in ADHD children (Section 3.2.1), and in SLI children (Section 3.2.2). The focus will be on inhibition, working memory, planning, cognitive flexibility and fluency, as these are the executive functions discriminated in the taxonomy of Pennington and Ozonoff (1996). However, before doing so, some methodological issues concerning the measurement of executive functioning will be addressed.

An executive functioning task is a complex task that assesses many interacting component processes. Pennington and Ozonoff (1996) mention four important problems in the measurement of executive functioning: (1) the tasks are not theoretically well-specified, (2) they do not allow the identification of different

component processes, (3) they are not always reliable and normally distributed, and (4) they do not appear to be sensitive to the same underlying processes across the range of performance. These measurement problems all contribute to what Pennington and Ozonoff call the 'discriminant validity problem'. That is, executive function deficits are seen in various disorders, not only in ADHD, but also in, for example, conduct disorder, autism, and Tourette syndrome. Executive function deficits are at least a correlate, and possibly also a cause of the disruptions in complex behavior in these disorders. This would imply that these disorders all involve a dysfunction of the prefrontal cortices. However, the question that Pennington and Ozonoff raise is how such a single deficit in the prefrontal cortices leads to such symptomatically different complex behavior disorders. Pennington and Ozonoff therefore propose that level and profile differences should be sought on executive functioning measures across disorders to at least partly solve the 'discriminant validity problem'.

Such methodological issues should be kept in mind when reading Section 3.2.1 about executive functioning in ADHD and Section 3.2.2 about executive functioning in SLI.

3.2.1 Executive functioning in ADHD

The review by Pennington and Ozonoff (1996) showed that 15 out of 18 studies found significant differences between ADHD subjects and controls (in the age range of 6 to 24-year-old) on one or more measures of executive functioning. A total of 60 different executive functioning measures were used across studies. The ADHD group performed significantly worse on 40 of these measures, and on no measure better. Pennington and Ozonoff concluded that (motor) inhibition is the main executive functioning deficit in ADHD. However, they also found problems on measures of working

memory, planning, and cognitive flexibility, although these findings were inconsistent across the studies reviewed[12].

Sergeant, Geurts and Oosterlaan (2002) reviewed performance of various clinical groups (4 to 40 years of age) on a number of executive functioning measures. Although they did find performance deficiencies in ADHD, most notably in inhibition, and less so in working memory, planning, cognitive flexibility and non-verbal fluency, no consistent pattern emerged between the different clinical groups. There did not appear to be a specific executive functioning profile for ADHD. Geurts, Verté, Oosterlaan, Roeyers and Sergeant (2004b) compared executive functioning in Dutch children with ADHD, children with high functioning autism and typically developing children (6-13 years of age). In general, children with higher functioning autism exhibited more profound problems than children with ADHD. However, ADHD children performed worse than typically developing children on measures of inhibition and verbal fluency.

According to Barkley (1997a, b, c), behavioral inhibition indeed is the primary executive functioning deficit in ADHD. In his model, this inhibitory deficit would in turn lead to other, secondary, executive functioning deficits. It is one of the most elaborate and comprehensive models of executive functioning in relation to ADHD. However, Willcutt, Doyle, Nigg, Faraone and Pennington (2005; also see Willcutt, Sonuga-Barke, Nigg and Sergeant, 2008) conclude in a meta-analytic review of the validity of the executive functioning theory of ADHD that executive functioning weaknesses in children and adolescents are neither necessary nor sufficient to explain the behavior of all cases of ADHD. However, they also state that difficulties with executive functioning, most notably in inhibition, but

[12] More detailed results about the performance of ADHD children on specific tasks/outcome variables will be discussed in Chapter 6. In this section, we mostly focus on the five executive function domains in general.

also in working memory and planning, are an important component of the complex neuropsychology of ADHD.

As a point of interest, several studies, e.g. the study by Kempton, et al. (1999), show that executive dysfunctioning in ADHD children is improved by stimulant medication.

In sum, the reviews and studies discussed in this section all point to a problem with (motor) inhibition in ADHD. Problems with non-verbal working memory, planning, cognitive flexibility and fluency are also reported, but the findings are not consistent. The 'discriminant validity problem', put forward by Pennington and Ozonoff (1996), cannot be solved on the basis of these studies. That is, it is still unclear how specific the executive functioning deficits are, and whether or not profile and level differences can be distinguished.

3.2.2 Executive functioning in SLI

Two different kinds of accounts try to explain the language problems in children with SLI. On the one hand, modular accounts, for example within the generative framework, claim that children with SLI have a defective innate grammar. The focus is on competence and representation. One of the problems is that they in general predict more severe grammatical deficits than that are actually seen in children with SLI. On the other hand, and more relevant for this study, non-modular accounts treat grammatical deficits of children with SLI as secondary to more general perceptual deficits, or deficits in, for example, working memory. These accounts focus on performance and processing. The fact that children with SLI show a partial mastery of grammatical rules supports such accounts. We will adopt a non-modular perspective in this study, also because the working hypothesis assumes an association between pragmatic

language and executive functioning, at least in children with ADHD (Tannock and Schachar, 1996).

This section will review the findings for the same five executive functions in SLI: inhibition, working memory, planning, cognitive flexibility and non-verbal fluency. Furthermore, we will try to establish whether or not level and profile differences, specific for SLI, can be distinguished (Pennington and Ozonoff, 1996). As of yet, there is no comprehensive review of the performance of SLI children on the five executive functions that have been so prominently researched in ADHD. Rather, different authors focus on different models in order to explain SLI children's language problems. Working memory usually plays a central role in these models, as well as attention[13].

Attention is often impaired in children with (S)LI. For example, a recent review of Ebert and Kohnert (2011) demonstrated substantial evidence for the occurrence of sustained attention deficits in LI children (3-20 years of age). Attentional control is also impaired in children with SLI (7-12 years of age), as has been demonstrated by Im-Bolter, Johnston and Pascual-Leone (2006). It should be noted that attention in ADHD research is generally not considered to be an executive function, although executive functioning does overlap with domains such as attention (Pennington and Ozonoff, 1996). Perhaps somewhat counter-intuitively, the deficit in attention in ADHD is not seen as a deficit in attentional capacity, because ADHD children do not appear to have deficits on tests of divided, selective or sustained attention (Sergeant and Van der Meere, 1990). Rather, the deficit is seen as one of attentional control, due to a failure to inhibit processing of, or responses to stimuli that are relevant to a task (e.g. Roodenrys, 2006). As a consequence, the ADHD literature seems to

[13] An example is Cowan's (2001) model of attention and memory, discussed in Gilliam, Montgomery and Gilliam (2009).

separate the research topics (i.e. attention on the one hand and executive functions on the other) more clearly than the SLI literature.

Many children with SLI exhibit significant working memory deficits relative to same-age peers (e.g. Montgomery, 2002). Most of the working memory research is based on the model of Baddeley (Baddeley, 1986; Gathercole and Baddeley, 1990; 1993; Baddeley, 2000). This model of working memory consists of several parts: the phonological loop, the visuospatial sketchpad, the episodic buffer and the central executive. The central executive is domain general and responsible for attentional control and regulation[14]. The phonological loop and the visuospatial sketchpad are domain specific and responsible for the temporary retention of, respectively, verbal material and visuospatial material. The episodic buffer is a relatively new component in the model (also see Baddeley, 2003); it is able to integrate input from both so-called slave systems (i.e. phonological as well as visuospatial input) into one coherent representation. Gathercole and Baddeley (1990) proposed that part of the language problems of children with SLI is attributable to poor phonological short-term memory. According to the authors, new linguistic material is placed in the phonological loop. The phonological representations in this loop fade quickly, unless reactivated through rehearsal. Only then does the material enter long-term memory. Problems in phonological short-term memory may be responsible for the below-age vocabularies of children with SLI. Moreover, it is possible that they adversely affect the comprehension of grammar as well as lexical verb learning (Gathercole and Baddeley, 1993). A considerable amount of research, reviewed by Leonard (2000), supports these claims. A

[14] The central executive in this model encompasses several of the five executive functions in the taxonomy by Pennington and Ozonoff (1996; see Section 3.2.1), such as inhibition and cognitive flexibility.

more recent review by Montgomery, Magimairaj and Finney (2010) also showed that SLI children, in comparison with same-age peers, demonstrate problems in all components of the working memory model of Baddeley. For Dutch LI children (5 years of age), problems in working memory are reported too (Van Daal, Verhoeven, van Leeuwe and van Balkom, 2008). In this study, these problems also predicted language abilities of the LI children. Phonological memory was found to predict phonological abilities (which in turn predicted syntactic abilities); central executive memory predicted lexical-semantic abilities; and visual memory predicted speech production abilities (Van Daal et al., 2008). In sum, when examining the working memory model of Baddely, the focus typically is on SLI children's verbal working memory (i.e. phonological loop). However, non-verbal working memory, (i.e. visuospatial sketchpad) is also affected in children with SLI.

Other studies, not specifically directed at the Baddely model, but aiming at non-verbal working memory capacity in SLI children also report problems. Marton (2008) showed that children with SLI (5- and 6-year-olds) perform more poorly than their age-matched peers on several visuospatial working memory tasks. Older SLI children (7- to 12-year-olds) also have problems in this domain (Im-Bolter et al., 2006; Lucács, Kas, Kemény and Krajcsi, 2010; Henry, Messer and Nash, 2012). In general, when problems with non-verbal working memory are reported, they seem to be associated more closely with language impairment than with ADHD (Cohen et al., 2000; also see Im-Bolter and Cohen, 2007). Only a few studies fail to find non-verbal working memory problems in children with SLI (Bavin, Wilson, Maruff and Sleeman, 2005; Archibald and Gathercole, 2006; Archibald and Joanisse, 2009 – age range 4-11 years of age).

Although the focus in the SLI literature is on models of working memory, research focusing specifically on non-verbal inhibition, planning, cognitive flexibility and fluency has also been conducted.

However, research in these areas, relative to working memory research, is sparse.

Im-Bolter, Johnston and Pascual-Leone (2006) found, among other things, that children with SLI (7-12 years of age) exhibit poor inhibitory control. Deficits in inhibition were also found by Henry, et al. (2012; mean age: 11.5 years) and by Lukács, et al. (2010; mean age: 10.5 years). Bishop and Frazier Norbury (2005) compared several measures of inhibition in four groups of children: children with high functioning autism, children with pragmatic language impairment, children with typical SLI and typically developing children (6-10 years of age). They found inhibitory problems for all three clinical groups.

According to Kahmi, Ward and Mills (1995), planning is not affected in children with SLI (5-7 years of age). However, this study only included a small number of children, and it did not use traditional planning tasks. Marton (2008) compared SLI children to typically developing children (8-11 years of age), and her results did point at some planning problems, although not unequivocally so. Weyandt and Willis (1994) did find that children with LI performed worse on a planning task than typically developing children (6-12 years of age). Interestingly, the scores of the LI children in this study did not differ significantly from the children with ADHD, which were also included in the study. The study by Henry, et al (2012) also pointed out that SLI children (mean age: 11.5 years) had lower planning scores than typically developing children. These SLI children performed at comparable level as a group of children with general low functioning.

The results with respect to cognitive flexibility are not consistent either. Williams, Stott, Goodyer and Sahakian (2000) found significant effects of hyperactivity, but not of specific language impairment on cognitive flexibility in 6-year-old children. Studies by Dibbets, Bakker and Jolles (2006), Henry, et al. (2012), Im-Bolter, Johnston and Pascual-Leone (2006), Kiernan, Snow, Swisher and

Vance (1997), and Weyandt and Willis (1994) did also not find difficulties with cognitive flexibility in (S)LI children (age range 4-12 years of age). On the other hand, Lukács, et al. (2010) did find problems with cognitive flexibility in the LI children (8-12 years of age) in their study. Moreover, Marton (2008) also found that cognitive flexibility was impaired in children with SLI (8-11 years of age).

Bishop and Frazier Norbury (2005) compared measures of verbal fluency in several groups of children (6-10 years of age). Verbal fluency was not impaired in SLI. Dunn, Gomes and Sebastian (1996) also did not find verbal fluency problems in SLI children compared to typically developing children (4-9 years of age). On the other hand, in a case study of an 11-year-old SLI child, verbal fluency was weak, although non-verbal fluency was normal (Koponen, Aro and Ahonen, 2009). There is only limited evidence available with respect to non-verbal fluency. Weyandt and Willis (1994) did not find non-verbal fluency problems in 6- to 12-year-old LI children. However, the study by Henry, et al. (2012) did find difficulties with non-verbal fluency in SLI children (mean age 11.5 years). This study by Henry, et al., mentioned several times in this section, is important. It is well designed, included a large number of children and measures, and controlled for age and non-verbal IQ.

In sum, there is evidence that children with SLI experience problems in non-verbal executive functioning. Problems with inhibition were found in all studies. However, studies reporting on working memory, planning, cognitive flexibility and fluency were less consistent; sometimes problems were reported, and sometimes problems were not reported.

It is difficult to draw firm conclusions since, compared to ADHD, relatively few studies about executive functioning in SLI are available. Thus, a comparison of the findings of the reviews in Section 3.2.1

and in Section 3.2.2 is difficult. Moreover, it is unclear how specific the executive functioning deficits in SLI are, and whether or not profile and level differences can be distinguished. The so-called 'discriminant validity problem', described by Pennington and Ozonoff (1996) is applicable to SLI as well as to ADHD.

Table 3-1 gives an overview of the affected executive functioning domains in children with ADHD and in children with SLI.

Non-verbal executive function	**ADHD**	**SLI**
Inhibition	++	(+)
Working memory	+/-	(+/-)
Planning	+/-	(+/-)
Cognitive flexibility	+/-	(+/-)
Non-verbal fluency	+/-	(+/-)

Table 3-1: affected non-verbal executive functioning domains in ADHD and SLI. ++ = salient problems; + = problems; +/- = problems possible; - = no problems. The brackets point at the limited availability of research, which makes it difficult to draw firm conclusions

Table 3-1 shows that ADHD children exhibit problems in inhibition, as do SLI children. The other executive functions are unclear. Both ADHD and SLI children may or may not encounter problems in working memory, planning, cognitive flexibility and fluency. So far, a direct comparison between ADHD and SLI children's performance on the five executive functions has not been conducted.

In this thesis, we will compare non-verbal executive functioning of children with ADHD, children with SLI and typically developing children. This is formulated in the second of the three research questions in this study:

Do children with ADHD differ in executive functioning in comparison with typically developing children and do they differ from SLI children?

The focus in this study will be on the five major executive functions, all tested non-verbally, that is inhibition, working memory, planning, cognitive flexibility and fluency (Pennington and Ozonoff, 1996).

3.3 Executive functioning in relation to language

The proposal of Tannock and Schachar (1996) that executive dysfunctioning may account for both the core behavioral problems and the pragmatic disorders commonly observed in ADHD, was briefly mentioned at the start of this chapter and will now be discussed in more detail.

Tannock and Schachar (1996) put forward several arguments to arrive at their proposal. First of all, they argue, on the basis of their literature review, that deficits in executive functioning are fundamental to ADHD and account for the core behavioral symptoms of the disorder. These deficits might be due to delayed frontal lobe maturation, possibly of genetic origin. Their second argument is that the prefrontal regions of the cortex are not only involved in the temporal organization of behavior, but also in the production and interpretation of language. More specifically, frontal lobe lesions disturb the regulatory function of speech; adults with frontal lobe lesions can no longer control their behavior with the aid of their own (inner) speech. Thirdly, their review of the types of communication disorders associated with ADHD reveals the strongest link to be between ADHD and problems in the expressive language domain, in particular in pragmatics. Pragmatic problems, placing heavy demands on for example planning, organization and monitoring, would indeed be predicted to occur in case of executive dysfunction. Finally, they argue that if executive dysfunctioning indeed underlies behavioral and pragmatic language problems in ADHD, treatment aimed at executive dysfunctioning should alleviate both kinds of problems. This indeed seems to be the case. For

example, ADHD stimulant medication is ameliorating overt behavioral symptoms, but there is also evidence that it ameliorates pragmatic symptoms.

It is important to realize that Tannock and Schachar (1996) relate problems in the basic language systems to reading disorders, and not to ADHD. In other words, Tannock and Schachar do not predict that phonology, morphology/syntax and semantics are related to executive functioning. Their proposal specifically focuses on pragmatic aspects of language[15].

Tannock and Schachar (1996) suggest a strong relation between EF and language. In this thesis this relationship will be explored in the third of the three research questions:

Is there an association between executive functioning and language measures in children with ADHD, children with SLI and typically developing children?

3.4 Overview research questions and general expectations

Section 2.1.2 and Section 2.2.2 discussed language in children with SLI and ADHD. It was found that SLI children encounter problems in all language domains, albeit to varying degrees. The problems in productive grammar are most noticeable. In the case of ADHD however, the picture is less clear, although there is strong evidence

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[15] The study by Van Lambalgen, Van Kruistum and Parigger (2008), discussed in Section 2.2.2, and preceding the study in the current thesis, aimed to shed more light on the relation between executive functioning, in particular planning, and language in Dutch ADHD children (7-9 years-old). However, in this study, problems with executive functioning were only hypothesized, and not tested empirically. Moreover, this study did not control for co-morbid reading disorders. So, it could be that the group difference that was found, not in pragmatics, which was not investigated in the study, but in one of the basic language systems, namely (morpho-)syntax, was due to high scores in those ADHD children who also exhibited reading problems.

that children with ADHD experience pragmatic language production problems. Section 3.2.1 and Section 3.2.2 on non-verbal executive functioning showed that ADHD children exhibit salient problems in inhibition, and that SLI children have noticeable problems in inhibition as well. However, it also became clear that we need to know more about the other four executive functions. Findings for working memory, planning, cognitive flexibility and fluency were inconsistent and/or too little evidence was available to warrant any firm conclusions.

The first two research questions are a consequence of these findings, and aim to shed more light on ADHD and SLI children's language (pragmatics and grammar) and their executive functioning (non-verbal inhibition, working memory, planning, cognitive flexibility, fluency):

1. *Do children with ADHD differ in language production in comparison with typically developing children and do they differ from SLI children (see Section 2.4)?*

2. *Do children with ADHD differ in executive functioning in comparison with typically developing children and do they differ from SLI children (see Section 3.2.2)?*

In general, the literature suggests that SLI children will primarily have language problems and that ADHD children will primarily have executive functioning problems. However, this might not be the case for pragmatic problems on the one hand (see Table 2-3) and inhibitory problems on the other hand (see Table 3-1). That is, these problems might be experienced by both the SLI and the ADHD groups.

The third research question aims to test the executive functioning theory of Tannock and Schachar (1996), which was discussed more extensively in Section 3.3:

3. *Is there an association between executive functioning and language measures in children with ADHD, children with SLI and typically developing children (see Section 3.3)?*

Tannock and Schachar's (1996) model suggests that pragmatic language measures will correlate with measures of executive functioning. They do not mention a specific executive function, but from the literature review it is possible that inhibition will show the highest correlation with pragmatic language measures. Correlations between measures of grammar and executive functions are not predicted by the model.

4

Research method

This chapter describes how the research questions, as set out in Section 3.4, will be answered. The selection of subjects is dealt with first (Section 4.1), followed by the procedure (Section 4.2), the various tasks (Sections 4.3 and 4.4), and the statistical analyses (Section 4.5).

4.1 Subject selection

In this section the characteristics of the children in the three research groups are discussed[16]. The research groups with typically developing children and with SLI children serve as controls to the research group with ADHD children.

Section 4.1.1 describes the inclusion and exclusion criteria used for the selection of the group with typically developing children. Section 4.1.2 provides further specifics of the SLI group, and Section 4.1.3 describes further specifics of the ADHD group. A summary of the details is presented in Section 4.1.4. More specifically: age, gender, non-verbal intelligence scores and symptoms of inattention and hyperactivity will be discussed.

[16] General characteristics of children with SLI and ADHD were already discussed in Sections 2.1.1 and 2.2.1 respectively.

4.1.1 *Typically developing group*

The typically developing children came from two state schools in the north of the Netherlands. The inclusion and exclusion criteria used are summarized in Table 4-1. The parents of the children received a background questionnaire to (double-)check these criteria[17]. It consisted of 29 questions, mostly multiple-choice, but also some open-ended items.

A total of 22 typically developing children participated in the study (see Table 4-2). More boys were selected than girls in order to make the gender split comparable to the ADHD group.

Inclusion criteria	Exclusion criteria
Age range 7;0-8;11	Physical/perceptual problems
Monolingual Dutch	Cognitive problems
	Psychiatric problems

Table 4-1: inclusion and exclusion criteria for the typically developing children

First of all, the children had to be 7 or 8 years of age. This age range was selected to match the desired age range for the ADHD group, and was chosen for two reasons: (1) ADHD is often not diagnosed before the age of seven and (2) ADHD language problems are most prominent before the age of nine. Secondly, only monolingual children were selected. This was because bilingualism might affect the language measure comparisons in the study (Genesee, 2003; Goorhuis and Schaerlaekens, 2000). Children with severe physical problems were excluded. In particular, problems in hearing and vision may affect language development (Mills, 1993; Mogford, 1993; Knoors, 2001; Baker, 2006). Cognitive problems may also affect language development (Chapman, 1995). Therefore, all children were tested for non-verbal intelligence (SON-R; Snijders,

[17] This questionnaire can be obtained by making a personal request to the author (e.m.parigger@uva.nl).

Oomen, Tellegen and Laros, 1988; also see Section 4.1.2). Furthermore, language development can be hampered by the presence of psychiatric problems (Blankenstijn & Scheper, 2003). So, in addition to the background questionnaire, which asked about psychiatric problems in general, an extra questionnaire gathered information about externalizing behavior in particular (VVGK; Oosterlaan, Scheres, Antrop, Roeyers and Sergeant, 2000; also see Section 4.1.3).

Originally, the TD group consisted of 25 children. Three children were excluded after the start of the study: one child was later diagnosed with ADHD; another child turned out to be bilingual, and the third was excluded at the discrimination of the researcher.

4.1.2 SLI group

The SLI children in this study came from two schools for language-impaired children in the north of the Netherlands. The inclusion and exclusion criteria from Table 4-1 also applied to the SLI group. A total of 19 SLI children participated in the study (see Table 4-2). The gender division was matched to that of the ADHD group.

The diagnostic label of SLI does not officially exist in the Netherlands. The diagnosis used is called 'ernstige spraak/taal-moeilijkheden' (ESM; severe speech/language deficits). It is normally made on the basis of the guidelines drawn up by Resing et al. (2005). They distinguish four problem areas: (1) auditory processing problems, (2) speech production problems (dyspraxia), (3) grammatical problems and (4) lexical/semantic problems. ESM is diagnosed when a child performs at least 1.5 SD below the mean on two subtests for at least two of the above problem areas, or when a child performs more than 2 SD below the mean on a general language test. This corresponds to the severity criterion of, for example, Stark and Tallal (1981) and Tomblin et al. (1997).

The SLI diagnosis is, however, also based on exclusion criteria (see Section 2.1.1). The school files of the children were consulted to ensure that no other clinical conditions, including ADHD, were diagnosed. Furthermore, intelligence was assessed using a non-verbal test for children in the age range of 5;6 up to 17 years (SON-R; Snijders, et al., 1988). This test consists of seven subtests, but the short version that was used in this study has four subtests and has been shown to be as valid and reliable as the longer version (Tellegen and Laros, 2003). The cut-off for non-verbal intelligence was set at 80. Taking a cut-off of 80 is not uncommon, also because intelligence does not correlate strictly with language outcomes (Fey, Long and Cleave, 1994; Bishop, 1997). Moreover, SLI children as a group tend to have somewhat lower scores, suggesting that low average intelligence is a common component of the SLI profile (e.g. Plante, 1998)[18].

Most studies in the international literature consider grammatical impairment to be the core problem area in SLI, either explicitly, or implicitly (see, for example, De Jong, 1999). For this reason, and in order to increase homogeneity in the SLI group, all children selected had to have at least grammatical problems. They were not excluded if they had auditory processing problems and/or lexical/semantic problems, but they were excluded if they had speech production problems (dyspraxia). The focus in this study is on language problems, not on speech problems. Furthermore, it would be difficult to interpret the results from children with speech problems on tests such as the non-word repetition test (see Section 4.3.2).

To summarize, when comparing the SLI group in this study to SLI groups in the international literature, this group mostly resembles 'typical SLI', described by Bishop (2004). As discussed in Section 2.1, she coined the term to refer to a distinctive subtype within the SLI group as a whole. This subtype is mainly defined by

[18] A cut-off of 80 is still well above the cut-off of 70 for mental retardation.

morphological/ syntactic problems (such as immature sentence structure and omission of grammatical morphemes), although phonological difficulties often occur as well.

The SLI group originally consisted of 23 children but four had to be excluded because their non-verbal intelligence score was below 80. Intelligence had to be tested during the course of the study, since testing beforehand was not possible (also see Section 4.2).

4.1.3 ADHD group

The general inclusion and exclusion criteria set out in Table 4-1 also applied to the ADHD group[19]. A total of 26 ADHD children participated in the study (see Table 4-2). Only ADHD children from the combined and from the mainly hyperactive-impulsive subtypes were included in the study. This is because the inattentive subtype may best be characterized as a distinct disorder (see review of Milich et al., 2001; also see Section 2.2.1). Inclusion of the inattentive subtype would make the ADHD group less homogeneous. ADHD is distributed unevenly over boys and girls in the general population, in a ratio of 80% to 20% (Gezondheidsraad, 2000). An effort was made to also reflect this distribution in the ADHD research group.

The ADHD children were recruited in two ways. They either came from an outpatient clinic for children and adolescents with psychiatric disorders, or they were found through an advertisement on the website and in the magazine of an association for parents of children with learning, developmental and/or behavioral disorders[20].

The outpatient clinic has three departments in the north of the Netherlands and all participated in this study. Several steps are taken in this clinic to ensure valid ADHD diagnoses, the most important

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[19] One of the ADHD children just turned 9;0 when tested. It was decided to keep him in the research group, but to observe closely whether or not his scores deviated from the scores of other ADHD children. This proved not to be the case.

[20] This parents' association is called BALANS. Their website can be found at www.balansdigitaal.nl.

being that the results of the children's individual reports (i.e. reports from intake and an anamnesis, a psychological report, a psychiatric report and observational reports from the home and school environment) are discussed in an interdisciplinary team consisting of psychiatrists, psychologists, and social workers. A diagnosis is only accepted if consensus can be reached.

Extra care had to be taken when considering ADHD children recruited via the parents' association. There is considerable variation in diagnosing ADHD in the Netherlands, and although it is done carefully at the clinic described above, it is not always the case elsewhere. In principle, it is even possible that the family doctor diagnoses ADHD on the basis of a 10-minute consultation. The parents of the children in the study were therefore asked to fill in a short additional questionnaire to provide details of the diagnosis[21]. Children were only included if they had also been seen by a paediatrician or a child psychologist/psychiatrist who had confirmed the ADHD diagnosis. Some of the children participating via the parents' association came from areas outside the urban area where the other children were tested. However, these children were included since they spoke standard Dutch, both at school and at home.

To further check on the ADHD diagnoses, the parents of all children who had given consent, and the teachers of these children completed a questionnaire on behavioral symptoms. This questionnaire is intended for children in the age range of 6 to 12 years and consists of 42 items, relating to behavioral symptoms listed in the DSM-IV categories of ADHD, ODD and CD (VVGK; Oosterlaan et al., 2000)[22]. The psychometrics of the VVGK questionnaire are reasonably good (COTAN, 2004). The parents' and/or the teacher's

[21] This questionnaire can be obtained upon application to the author (e.m.parigger@uva.nl).
[22] The VVGK is a translation of the well-known questionnaire on disruptive behaviour disorders (DBD; Pelham, Gnagy, Greenslade and Milich, 1992).

scores on the scales hyperactivity-impulsivity/inattention had to fall in the (sub) clinical range for the ADHD children to be included.

From the original set of 28 ADHD children, two had to be excluded: one could not be tested for the second and third time due to illness; another because one of his parents mainly spoke English to him.

4.1.4 *Overview of subjects*

In Table 4-2, age in months and gender of the children in the ADHD group, the SLI group and the TD group are presented. Non-verbal intelligence (SON-R; see Section 4.1.2) and ADHD symptoms (VVGK; see Section 4.1.3) are also reported for these three groups.

	ADHD (n=26)	**SLI (n=19)**	**TD (n=22)**	**Total (n=67)**
Age in months (mean and SD)	97.73 (6.32)	99.74 (5.60)	97.59 (5.80)	98.25 (5.93)
Gender–male (% and n)	81% (21)	79% (15)	73% (16)	78% (52)
Gender–female (% and n)	19% (5)	21% (4)	27% (6)	22% (15)
Non-verbal IQ (mean and SD)	108.65 (12.55)	98.00 (13.59)	112.95 (10.45)	107.04 (13.45)
ADHD symptoms (mean and SD)	35.15 (9.26)	13.71 (8.06)	8.18 (8.09)	20.74 (15.11)

Table 4-2: age in months, gender, non-verbal IQ (SON-R) and ADHD symptoms (VVGK; summed totals of scales hyperactivity-impulsivity and inattention) in ADHD, SLI and TD groups. Data on symptoms of ADHD are missing for 5 of the 19 children with SLI

The three research groups were matched for age in months as far as possible. The mean age across all groups is 98.3 months (i.e. 8

years and 2 months) and there was no significant difference in age between the ADHD, SLI and TD groups, $F(2, 64)=.827$, $p>.05$.

There was a representative but uneven gender distribution in the ADHD group (see Sections 2.2.1 and 4.1.3), that is, 81% boys and 19% girls. The SLI and TD children were selected in order to reflect this distribution.

Due to time constraints, it was not possible to match the children for intelligence[23]. There turned out to be significant differences in IQ scores, $F(2, 64)=8.00$, $p<.05$. More specifically, the SLI group had a lower IQ than both the ADHD group ($p=.015$) and the TD group ($p=.001$). The ADHD group and the TD group did not differ from each other ($p=.537$).

As expected, there also were significant differences between the summed hyperactivity-impulsivity and inattention scale scores of the ADHD, SLI and TD groups, $F(2, 59)=64.68$, $p<.05$. More specifically, as might be expected, the ADHD group has more such symptoms than both the SLI group ($p=.000$) and the TD group ($p=.000$). Moreover, the scores of the ADHD children are in the (sub)clinical range. The SLI group does not differ from the TD group ($p=.176$).

Oppositional defiant disorder (ODD) and conduct disorder (CD) frequently co-occur with ADHD (e.g. Biederman, Newcorn and Sprich, 1991). Reading problems are also very common among children with ADHD (Gilger, Pennington and DeFries, 1992). It was not possible to exclude all ADHD children with one or more of these conditions (also see Section 2.2). However, the children were screened for ODD, CD and RP. We did this not only for the ADHD children, but also for the SLI and TD children. ODD and CD were assessed using the behavioral questionnaire, VVGK, as discussed in

[23] Matching for intelligence would mean testing a large pool of SLI children, because, as a group, they tend to have lower intelligence scores (e.g. Plante, 1998; also see Section 4.1.2).

Section 4.1.3. To assess RP, two standardized reading tasks were used: a real word task (RWT; Brus and Voeten, 1973) and a pseudo-word task (PWT; Van den Bos, Lutje Spelberg, Scheepstra and de Vries, 1994). Raw scores on both tasks were converted to standardized scores with a mean of 10, and a SD of 3. RP is deemed to be present when children score more than 1 SD below the mean on both tasks.

	ADHD (n=26)	**SLI (n=19)**	**TD (n=22)**	**Total (n=67)**
ODD (% and n)				
normal	69% (18)	86% (12)	86% (19)	79% (49)
subclinical	12% (3)	7% (1)	14% (3)	11% (7)
clinical	19% (5)	7% (1)	0% (0)	10% (6)
CD (% and n)				
normal	77% (20)	79% (11)	91% (20)	82% (51)
subclinical	19% (5)	7% (1)	4.5% (1)	11% (7)
clinical	4% (1)	14% (2)	4.5% (1)	7% (4)
RP (% and n)				
present	23% (6)	68% (13)	18% (4)	34% (23)
not present	77% (20)	32% (6)	82% (18)	66% (44)

Table 4-3: presence of co-morbid oppositional defiant disorder (VVGK), conduct disorder (VVGK), and/or reading disorders (RWT/PWT) in the ADHD, SLI and TD groups. Data on ODD and CD are missing for 5 of the 19 children with SLI

Table 4-3 shows the results of the screening for co-morbid oppositional defiant disorder (ODD) and conduct disorder (CD), as well as the screening for co-morbid reading problems (RP) in the ADHD group, the SLI group and the TD group. Data on ODD and CD will not be used in further analyses, and are displayed solely for information. Data on RP, however, will be used, in particular in Chapter 5 and 8.

4.2 Procedure

The parents of the children received an information letter, consent forms and several questionnaires when their children were selected. Most of them returned the forms and questionnaires within the testing period. Three parents failed to respond after several reminders. All were parents of SLI children, which means that fewer data are available for the SLI group. Their consent forms were collected via the contact person at school or via the people that treated the children.

The information letter contained precise information about the project, and about what was expected. It also provided information about who to approach in case of questions or complaints. The parents signed the informed consent form, also signed by the researcher, indicating that they were willing to participate in the study. On another form, they indicated whether or not they wanted the school or the family doctor to be informed about the results, when necessary. Moreover, they also indicated whether or not their child's individual results could be used for presentations and/or publications. The three questionnaires were the background questionnaire (see Section 4.1.1), the behavioral questionnaire (see Section 4.1.3) and the language questionnaire (see Section 4.3.3).

The children were tested three times within as short a period of time as possible. This was preferably within three weeks, but eight weeks was the maximum. The sessions took place during school hours, mostly in the mornings, and were conducted in a separate room with no other people present. Each session lasted 45-90 minutes, including some time for informal talk. Most of the children were tested by the researcher. She has a background in clinical psychology and psycho- and patholinguistics. Some of the typically developing children were tested by two interns with a background in clinical linguistics, but only after extensive training by the researcher. In the first session the intelligence test (see Section 4.1.1) was

administered, and in the other two sessions language and executive functioning were assessed (see Sections 4.3 and 4.4). The language assessment was recorded on a digital video camera (Panasonic NV-GS75). It included a narrative task, a non-word repetition task and a sentence imitation task, as well as the two reading tasks already described in Section 4.1.3. The neuropsychological assessment contained measures of inhibition, working memory, planning, flexibility and non-verbal fluency. The order of testing, between and within the sessions was counterbalanced. There was one exception to this rule; the language assessment always started with the narrative task. As requested when entering the project, the children did not use any sort of medication (for example methylphenidate) before and during the language and neuropsychological sessions.

This was verified with both the parents and the children themselves before starting the sessions. After each successful session, the children received a token and at the end of the testing period, they received a small present. They all indicated that they had enjoyed themselves. The parents of the children in all three groups received a short descriptive summary of the performance of their child. In particular, feedback was given on the intelligence results and some of the more general language results.

4.3 Language assessment

As we saw in Section 2.2.2, children with ADHD have some problems with grammar and more severe problems in pragmatics. These language domains in particular will be the focus of this study (also see Section 2.4).

A summary of all tasks and outcome measures in the language assessment is presented in Tables 4-4 and 4-5. In Sections 4.3.1, 4.3.2 and 4.3.3, these tasks will be described in more detail.

Frog story (narration)	Outcome measures
General	number of analyzable T-units, total number of utterances not related to the story, total number of non-analyzable utterances, mean length of utterance (in words), percentage of subordinate conjunctions, percentage of dysfluencies, percentage of direct speech
Grammar	percentage of morpho-syntactic errors, percentage of morphological errors, percentage of syntactic errors, percentage of clustered morpho-syntactic errors
Pragmatics	total number of plot elements, total number of setting elements, total number of initiating events, total number of internal responses, total number of search attempts, total number of goals

Table 4-4: overview of outcome measures, subdivided in general, grammatical and pragmatic measures, in narrative task (frog story) used in language assessment

Language tasks and questionnaire	Outcome measures
ZIT	number of items correct (out of 20)
NWR	number of items correct (out of 16), percentage of phonemes repeated correctly
CCC-II-NL	scales (10x): speech production, syntax, semantics, coherence, inappropriate initiation, stereotyped language, use of context, non-verbal communication, social relations, interests
	composites (3x): general communication score, social interaction score, pragmatic score

Table 4-5: overview of outcome measures in repetition tasks (sentence imitation task [ZIT] and non-word repetition task [NWR]) and language questionnaire [CCC-II-NL] used in language assessment

4.3.1 Narrative task

The book *Frog, where are you?* (Mayer, 1969) is for children, and has no text but only pictures. It has been used widely in international research, mainly for studies looking at the development of narrative abilities (Berman and Slobin, 1994). The story is about a boy who searches, together with his dog, for his lost frog. He looks in several places, but is unable to find the frog. In the end, however, he does find the frog and takes him back home. The story has a clear protagonist, who faces a problem, tries to solve it, and finally is able to come up with a solution. Dutch children in the targeted age rangeare used to these kinds of stories, and they are also familiar with storytelling (Roelofs, 1998). The stories produced by the children can be considered examples of semi-spontaneous language use.

The children were asked to flip through all pictures in the book before starting their narration. This was done to give them an overall idea of what was coming in order not to overload working memory when actually performing the narrative task itself. The experimenter then labeled the boy, the dog and the frog, and pointed at them. She then asked the children to look at the pictures again in sequence and while so doing to tell the story in their own words. She pretended to not know the story and made it clear that she could not see the pictures in the book herself. Feedback was given as little as possible. To be sure that the story had been well understood by the children, some comprehension questions were asked afterwards. All children were able to answer these questions.

The narratives produced by the children were transcribed by the researcher or by one of her interns - all with a background in clinical linguistics. The transcriptions were divided in T-units, using CHAT (MacWhinney, 2000). A T-unit is an abbreviation of terminable unit and it is defined as one main clause plus any subordinate clause or non-clausal structure that is attached to or embedded in it (Hunt,

1970: 4). The transcriptions were double-checked and disagreements were solved after discussion between the researcher and the interns (also see Section 4.5.3). T-units with unintelligible words or unfinished T-units were considered not to be analyzable and coded as such. Elliptical utterances were also considered unanalyzable. The remaining analyzable T-units were divided into utterances that were related to the frog story, and those not related to the frog story. The former utterances were of interest for the analyses described in the remainder of this section (henceforward referred to as 'T-unit(s) of the narrative'). The analyses were done on a grammatical and on a pragmatic level as set out in Sections 2.4 and 3.4.

The grammatical analyses described below are based on analyses in the Dutch STAP-procedure (Van den Dungen and Verbeek, 1999). This procedure is used both for language-disordered children and for children whose language is developing normally. It is the only method available for Dutch children in the age rangeof the study. It is aimed at 4- to 8-year-old children and determines the language production level in spontaneous conversations 'outside the here and now'. However, STAP proved to be perfectly applicable to the semi-spontaneous language use in the frog stories, which can obviously also be considered as 'outside the here-and-now' language use.

First of all, the mean number of dysfluencies in the T-units of the narrative was determined. Four categories of dysfluencies were distinguished: (1) false starts, (2) self-corrections, (3) repetitions and (4) mixed constructions[24]. False starts were identified when a child restarts an utterance, in a way different from the previous start of that

[24] Pause words (e.g. 'uh') were counted separately because they were not considered to be dysfluencies in the same sense as false starts, self-corrections, repetitions and mixed constructions. Rather, they seem to reflect something like 'thinking time'.

utterance, see Example [1][25]. In a self-correction, a child replaces part of a word or more while expressing the utterance, without starting the utterance anew, as in Example [2]. A repetition, as shown in Example [3] is a literal recurrence of part of a word or more. Finally, in a mixed construction a child starts the utterance as if going to form one structure, but then completes the utterance with a different structure. Words often become redundant when this happens, as can be seen in Example [4]. All (categories of) dysfluencies were totalled and divided by the total amount of T-units of the narrative.

[1] <u>de bij</u> het jongetje keek in een hol
'<u>the bee</u> the little-boy looked into a hole'
(ADHD26, male, 7;4.14 - coded as false start)

[2] en die is <u>zit</u> in een pot
'and he is <u>sits</u> in a jar'
(TD18, male, 7;3.26 - coded as self correction)

[3] waar ben je <u>waar ben je</u>
'where are you <u>where are you'</u>
(SLI18, male, 8;7.1 - coded as repetition)

[4] het jongetje houdt met zijn hand <u>houdt ie</u> het raam vast
'the little-boy holds with his hand <u>holds he</u> on to the window'
(ADHD7, female, 7;4.13 - coded as mixed construction)

Secondly, the mean length of utterance (MLU) was computed in order to obtain a global estimate of syntactic complexity. MLU was not calculated in morphemes, but in words, which is more appropriate given the advanced age of the children in this study

[25] Examples [1] to [17] are taken from data from this study. Participant group and number, as well as gender and age are given between brackets. All Dutch examples are translated into English. In general, the erroneous part of an utterance will be indicated by underlining. An asterisk is used whenever a certain linguistic form seems accurate in English, but is not in Dutch.

(Wells, 1985). More specifically, for the MLU, all communicatively used words (i.e. not including dysfluencies) in the T-units of the narrative were added up and then divided by the total amount of T-units of the narrative. As an additional measure of syntactic complexity, all subordinate conjunctions were totalled and divided by the total amount of T-units of the narrative. The use of subordinate conjunctions is indicative of more advanced linguistic abilities.

Thirdly, a grammatical error-analysis was carried out. According to STAP, errors in the inflection or conjugation of a verb, a noun, or an adjective are specified as separate morphological errors (see Examples [5], [6] and [7] respectively). Other morphological errors were allocated to a category 'other'.

[5] de hond en de jongetje <u>slaap</u>
'the dog and the* little-boy <u>sleep</u>'
(SLI1, male, 7;11.16 - coded as verb conjugation error)

[6] (...) die kikker samen met een vrouwtje en allemaal jonkietjes
'(...) that frog together with a little-female and a lot of <u>little-ones</u>'
(TD3, female, 8;4.0 - coded as noun conjugation error)

[7] en dan nemen ze één <u>kleine</u> kikkertje mee
'and then they take one <u>little*</u> little-frog with them'
(ADHD20, female, 8;8.11 - coded as adjective conjugation error)

Syntactic errors are interpreted as errors in the structure of the utterance, caused by deletion, insertion, substitution or inversion (see Examples [8], [9] and [10]. Other syntactic errors were coded as 'other'.

[8] plotseling ___ de kikker weg
'all of a sudden the frog ___ gone'
(SLI4, male, 7;11.14 - coded as deletion)

[9] toen het nacht was en het jongetje die sliep kroop de kikker (...)
'when it was night and the boy who slept the frog crawled (...)'
(ADHD19, female, 8;3.14 - coded as insertion)

[10] want zit ie daar met z'n hoofd in
'because sits he in there with his head'
(TD7, female, 8;5.15 - coded as inversion)

The percentage of morphological and the percentage of syntactic errors will be calculated over all T-units of the narrative. The percentage of the combined morphological and syntactic errors will also be calculated over all T-units of the narrative. Clustering of grammatical errors in a single utterance will also be considered, that is the percentage of T-units of the narrative having more than one grammatical error (see also Blankenstijn and Scheper, 2003).

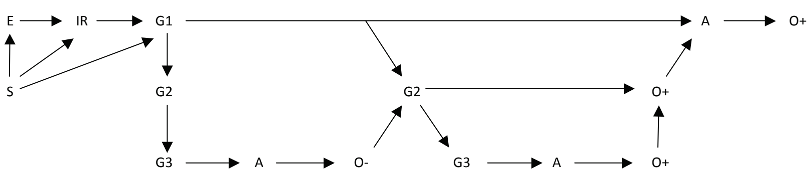

Figure 4-1: illustration of the causal network model by Trabasso and Rodkin (1994). S=setting; E=event; IR=internal response; G1=goal 1, get frog back; G2=goal 2, find frog; G3=goal 3= search frog in particular locations; A=search attempt; O=outcome (positive or negative)

The main pragmatic analysis in this study is the plot analysis. As indicated in Section 2.2.2, ADHD children have been shown to have striking problems with the organization and monitoring of their narratives. The plot analysis will show up such problems. It focuses on the causal relations between the narrative events in the frog story.

The causal network model by Trabasso and Rodkin (1994) is shown in Figure 4-1. It forms the basis for the plot analysis in this study.

Trabasso and Rodkin (1994) argue that the frog story follows a hierarchical goal plan with unanticipated goal failures, goal reinstatements and goal successes. The plan begins with a setting (S; the boy has a pet frog), which is followed by an event (E; loses it) that happens to a protagonist. These respectively enable and psychologically cause an internal reaction (IR; shows concern over loss). The reaction leads to a goal (G1; plan to get the frog back). This goal motivates a subordinate goal (G2; plan to find the frog) to obtain it. The subordinate goal (G2) in turn motivates another subordinate goal (G3; plan to search for the frog in particular locations) to obtain it. Together those three goals constitute a plan. The plan is carried out through actions motivated by the third goal in the hierarchy (G3). This goal motivates an initial attempt (A; looking or calling) that fails as indicated by a negative outcome (O-; frog is not found and animals other than the frog suddenly appear). This failure is monitored and psychologically causes the reinstatement of the second goal (G2) that is motivated by the first goal (G1) that controls the overall plan. The frog story repeats this cycle six times. Finally, the seventh time, an attempt leads to a successful outcome (O+) for the third goal. This outcome enables another succesful outcome (O+) at the level of the second goal (G2). This outcome causes a successful outcome (O+) for the first goal (G1), thus completing the hierarchical goal plan.

There is an extensive international research tradition based on the causal network model by Trabasso and Rodkin (1994). Blankenstijn and Scheper (2003) and Roelofs (1998) added some features to this analysis model. The scoring system focuses on whether certain narrative events, the so-called planning components, are reported. Planning components are only scored when a complete state of affairs (i.e. subject with verb) is present. In other words, when a

certain planning component is not accompanied by a subject and a verb, that component is not scored. Furthermore, the planning components have to be related when looking at the corresponding page in the booklet and from the viewpoint of the boy, possibly in combination with the viewpoint of his dog.

Category	**Planning components**	**Page**
Setting	introduction boy, dog, frog	1
	boy possesses frog	1
Initiating events	boy asleep	2
	frog leaves jar	2
	boy awakes	3
	boy finds jar	3
	jar is empty	3
	frog is gone	3
Internal response	boy is sad	3
Search attempts	boy searches frog in room	4
	boy calls frog out of window	5
	boy searches frog outside	8
	boy searches frog in hole in ground	9
	boy searches frog in hole in tree	11
	boy calls frog from rock	14
	boy searches behind log	21
Outcome	boy finds the frog/a(nother) frog	22
	boy retrieves the frog/a(nother) frog	24
Internal response	boy is happy	24

Table 4-6: all possible planning components of the frog story, divided over five categories. The corresponding pages in the booklet are also mentioned

A total of 19 planning components is distinguished and divided over five categories: (1) setting, (2) initiating events, (3) internal respon-

ses, (4) search attempts[26] and (5) higher order goals. A complete list is shown in Table 4-6.

Examples [11], [12], [13], and [14] and [15] provide illustrations of each category from the frog story transcripts.

[11] er is een jongen met een hond en een kikker
'there is a boy with a dog and a frog'
(ADHD9, male, 8;10.6 - coded as setting: introduction)

[12] en de kikker is weg
'and the frog is gone'
(SLI13, male, 8;7.12 - coded as initiating event: frog gone)

[13] en het jongetje ging in de boom kijken waar de kikker was
'and the little-boy went in the tree to look for the frog'
(SLI9, female, 8;5.2 - coded as search attempt: hole tree)

[14] Tom ging weer naar huis met de kikker
'Tom went home again with the frog'
(TD19, male, 8;5.9 - coded as outcome: boy retrieves frog)

[15] Jan moet heel erg hard lachen
'Jan has to laugh really loud'
(ADHD25, male, 8;10.5 - internal response: boy happy)

In each transcript the planning components were coded and counted with CLAN. The variables of interest are the total number of worded planning components and the total amount of worded planning components in each of the categories.

[26] Within the category of search attempts, a further differentiation is made in the location of a search attempt, (room, hole in tree etc.), the goal of a search attempt (frog), the action of a search attempt (subject with verbs like look, search, etc.) and the outcome of a search attempt (failure or success). A complete search attempt is only scored when action, goal and location are mentioned. When, in addition, the outcome is also mentioned, this is called a GAO-unit.

Finally, all uses of direct speech in the frog stories were coded (see Section 2.2.2). A distinction was made between direct speech with mention of the speaker, see Example [16], and direct speech without mention of the speaker, see Example [17]. The former is more sophisticated than the latter, but probably takes more processing effort, thus potentially placing an extra burden on executive functioning. All direct speech variables were counted and then divided by the total amount of T-units of the narrative.

[16] hij ging op de rots staan en riep: /"kikker, kikker"
'he went to stand on the rock and shouted: / "frog, frog" '
(ADHD22, male, 7;10.10 - coded as direct speech with mention speaker)

[17] "stoute hond"
' "naughty dog" '
(TD22, male, 7;3.11 - coded as direct speech without mention of the speaker)

4.3.2 Repetition tasks

Two different repetition tasks were administered: the sentence imitation task and the non-word repetition task.

The Dutch sentence imitation task that was used, the 'zinnen imitatie taak' (ZIT), was developed by Kraan-aan de Wiel (1989). Norm groups are available for this task. The task includes 20 sentences of varying complexity (and four practice items). The sentences are four to 10 words long, with a mean of 7.6 words. An example is shown in [18].

[18] gaan wij vanmiddag naar het zwembad?
'are we going to the pool this afternoon?'

The sentences were spoken by a female native speaker, pre-recorded and played back, only once, on a laptop computer with loudspeakers. The responses were recorded on a digital video camera and were transcribed after the testing session. Each sentence was scored either as 'right' or as 'wrong'. Poor performance on the sentence imitation task reflects grammatical problems. All scores were double-checked, and inconsistencies were resolved by the two coders (the researcher and one of the interns with a background in clinical linguistics). Additionally, qualitative analyses were performed on the error categories of this sentence imitation task (Dijkhuizen, 2010). These results will be summarized (see Section 5.2).

The Dutch non-word repetition task was developed by De Bree (2007), based on Dollaghan and Campbell's task (1998). It contains 16 non-words of two to five syllables in length that conform to the Dutch phonotactic system. For each syllable length there are four items and the task starts with three practice items. The items do not contain any consonant clusters. Examples are *so:taif* and *be:putamu:f*. The non-words were pre-recorded by a female native speaker. They were played back on a laptop computer with loudspeakers. Repeated presentations of the items were not allowed. The responses of the subjects were recorded on a digital video camera and were transcribed after the testing session. The responses were scored as either 'right' or 'wrong'. The percentage of phonemes repeated correctly for each word type (2-5 syllable words) was also calculated. Poor performance on the non-word repetition task reflects 'poor encoding, storage and retrieval of phonological representations (De Bree, 2007: 112)[27]. All scores were double-checked, and inconsist-

[27] The relation between scores on these verbal repetition tasks on the one hand and non-verbal working memory on the other hand will be discussed in Section 7.1.1.

encies were resolved by the two coders (the researcher and one of the interns with a background in clinical linguistics).

4.3.3 Language questionnaire

The children's communication checklist-II, developed by Bishop (2003), was used as a general language measure. This questionnaire covers the child's language use, focusing in particular on pragmatics (the main level of analysis in this study). The primary goal of this questionnaire is to obtain information on a broad range of pragmatic variables that supplements the more in-depth pragmatic analyses of the semi-spontaneous narrative samples (see Section 4.3.1). An additional advantage is that it offers a different perspective on the pragmatic skills of the children, since it is filled in by their parents. Information on various other aspects of language (for example phonology, syntax and semantics) can also be collected with the help of this questionnaire. A standardized Dutch translation of the questionnaire, produced by Geurts (CCC-II-NL; 2007), was available for children from 4 to 15 years of age. It consists of 70 items, divided into statements about possible weaknesses and statements about possible strengths of the child. Examples are given in [19] en [20]. The psychometrics of the CCC-II-NL generally are satisfactory (COTAN, 2004).

[19] lacht op gepaste momenten wanneer hij/zij met anderen praat
'laughs at appropriate moments when he/she talks with others'

[20] stelt een vraag hoewel hij/zij het antwoord al heeft gekregen
'asks a question although he/she has already received the answer'

The questionnaire has a multiple-choice format, with the possibility of choosing from four options (corresponding to the raw scores 0, 1, 2 and 3 respectively): 'less than once a week; never', 'at least once

a week, but not every day', 'once or twice each day' and 'several times each day (or more than two times a day); always'. The items are divided over 10 scales: (1) speech production, (2) syntax, (3) semantics, (4) coherence, (5) inappropriate initiation, (6) stereotyped language, (7) use of context, (8) non-verbal communication, (9) social relations and (10) interests. Each scale has five positively worded items and two negatively worded items, resulting in a minimal raw score of 0 and a maximal raw score of 21. From these scales three composite scores can be derived: (1) the general communication score, based on scales 1 to 8 (2) the social interaction score, based on scales 1-5 and scales 8-10 and (3) the pragmatic score, based on scales 5-8. Normally, a general communication score above 104, which equals the 90^{th} percentile, is taken as indicative of an SLI diagnosis. The interpretation of the general communication composite and the pragmatic composite is quite straightforward; higher scores mean more problems. However, this is not the case for the social interaction composite, where the interpretation is altogether different. This score is used to classify children, predominantly in research contexts. Children with a low negative social interaction score will mainly have structural language problems (as in SLI). Children with a high positive social interaction score will mainly have pragmatic problems (as in autism spectrum disorders).

4.4 Neuropsychological assessment

As set out in Sections 3.1 and 3.2, Pennington and Ozonoff (1996) discriminate between five executive functions: inhibition, working memory, planning, cognitive flexibility and non-verbal fluency. These executive functions will be tested in this study. The focus will be on non-verbal abilities in order to minimize the confound with linguistic abilities.

In order to standardize measurement of executive functioning as much as possible, we chose to use an automated neuropsychological testing battery, the CANTAB testing battery (Cambridge Cognition Limited, 2006)[28]. The CANTAB battery was selected since it appeared more valid and reliable than other batteries available at the time of the study. CANTAB has been standardized on a large population aged between 4 and 90 in various studies (Strauss, Sherman and Spreen, 2006). Good levels of test-retest reliability have been reported (e.g. Fowler, Saling, Conway, Semple and Louis, 2002). Its validity has been established in a wide range of clinical populations (e.g. Fray, Robbins and Sahakian, 1996). More specifically, Williams et al. (2000) looked at SLI and hyperactivity, using the CANTAB. They included four groups of 6-year-old children: children with SLI, children with hyperactivity, children with SLI and hyperactivity and typically developing control children. SLI was not associated with reduced performance on any of the neuropsychological measures. Hyperactivity was associated with deficits on a test of attentional set shifting. They also had reduced spatial spans on a test of spatial working memory. There were no interactions. These results should be interpreted with caution however, because the children with hyperactivity were not officially diagnosed with ADHD. Moreover, the research groups were quite small.

From the CANTAB testing battery, six tests were selected. Two of these were control tests[29], passed by all children. Four measured executive functioning, in particular: inhibition (SST), spatial working memory (SWM), planning (SOC) and cognitive flexibility (IED - also

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[28] The CANTAB bibliography (see http://www.cantabbibliography.co.uk) contains over 700 peer-reviewed articles, all making use of CANTAB.
[29] The MOT (motor screening; relevant as a control test for all other tests) and the BLC (big/little circle; relevant as a control test for the IED).

see Table 4-7)[30, 31]. The specific tests, with their outcome measures, will be described separately in the remainder of this section.

Function	Test	Outcome measures
Inhibition	CANTAB-SST (stop signal task)	• SSRT
Working memory	CANTAB-SWM (spatial working memory)	• between-search errors • within-search errors • strategy score
Planning	CANTAB-SOC (stockings of Cambridge)	• problems solved in minimum moves • mean moves for n-move problems
Cognitive flexibility	CANTAB-IED (intra-/extradimensional shift)	• stages completed • total trials (adjusted) • errors blocks 2/5/7/9 • errors blocks 6/8
Non-verbal fluency	Paper-and-pencil-FPT (five point test)	• unique designs (%) • perseverations (%)

Table 4-7: tests and outcome measures used in the neuropsychological assessment

The stop signal task (SST; clinical mode[32]) is a classic stop signal task, which uses staircase functions to generate an estimate of stop

[30] A test for fluency is not available in the CANTAB testing battery. This executive function is thus tested with a paper-and-pencil test, and will be described later on in this section.
[31] It would have been informative to complement the tasks from this battery with the behavior rating inventory of executive funtion (BRIEF; Huizinga and Smidts, 2011). However, in the preparation phase of this study, this questionnaire was not yet available.

signal reaction time. The test gives a measure of a subject's ability to inhibit a prepotent response (Aron, Dowson, Sahakian and Robbins, 2003). It takes around 20 minutes to administer. The task screen for the SST shows a white ring displayed to alert the subject, after which an arrow pointing to either the left or the right is displayed (see Figure 4-2). The test consists of two parts. In the first part, the subject is introduced to the press pad, and told to press the left hand button when a left-pointing arrow is shown and the right hand button when a right-pointing arrow is shown. In the second part, the subject is told to continue pressing the buttons as before, but to withhold the response, i.e. not press the button, when a beep is heard. This second part of the SST contains five blocks. At the end of each block, a feedback screen is displayed showing a graphical representation of the subject's performance, which the administrator then explains to the subject, as well as encouraging them to go faster.

Figure 4-2: screenshot of the SST

One SST outcome measure was selected for this study: stop signal reaction time (SSRT – last half). SSRT is an estimate of the length of time between the go stimulus and the stop stimulus at which the subject is able to successfully inhibit their response on 50% of trials. SSRT is calculated with the help of the stop signal delay (SSD) and the median reaction time on go trials (MRT-GT). The MRT-GT is self-explanatory. The SSD is calculated on the basis of the stop trials. In the stop trials, the auditory tone is played after the stop signal delay period. The timing of the auditory stop signal changes throughout the test. That is,

[32] Actually, the clinical mode was used for all CANTAB tasks that were selected for this study. The clinical mode is used when running the task only once per subject, and can be opposed to parallel mode, if available, for repeated testing.

sometimes the stop signal delay period is shorter, and sometimes it is longer. This depends on the subject's past performance. Stopping should only be possible approximately 50% of the time. The dependent measure was calculated on the last half of the assessed sub-blocks in the test.

Spatial working memory (SWM; clinical mode) is a test of the subject's ability to retain spatial information and to manipulate remembered items in working memory. It is a self-ordered task, which also assesses the use of a heuristic strategy (Owen, Downes, Sahakian, Polkey and Robbins, 1990). It takes about eight minutes to administer. The aim of the test is to fill up an empty column on the right hand side of the screen with blue tokens found, by using a process of elimination, in colored squares (boxes). The test begins with a number of boxes being shown on the screen (see Figure 4-3). The subject is instructed to search for blue tokens within these boxes. Touching a box reveals what is inside. Once a blue token has been found within a particular box, that box will never be used again to hide a token. Searching goes on until all blue tokens have been found. The number of boxes to be searched on the screen gradually increases over the trials, from 3 to 4 to 6 to 8 boxes. The color and position of the boxes used are changed from trial to trial to discourage the use of stereotyped search strategies.

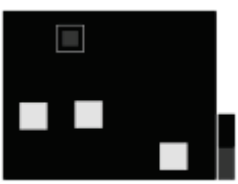

Figure 4-3: screenshot of the SWM

Three SWM outcome measures were selected for this study: two error-scores and one strategy-score. Returning to an empty box where a blue token has already been found is referred to as a between-search error. A within-search error refers to responses to a box previously opened and shown to be empty. The strategy score is

based on the number of searches that start from the same location. A low strategy score signals better performance and is given to search sequences that consistently start from the same box. The dependent measures were calculated on 3-, 4-, 6- and 8- box problems.

The SWM and the sentence imitation/non-word repetition tasks (ZIT and NWR, see Section 4.3.2) all involve memory, although the former is non-verbal. It could therefore be the case that scores on the NWR will correlate with scores on the SWM (see Section 7.1.2).

Stockings of Cambridge (SOC; clinical mode) is a test of spatial planning (Morris, Downes, Sahakian, Evenden, Heald and Robbins, 1988). It takes around 10 minutes to administer. The subject is shown two displays containing three colored balls (see Figure 4-4). The subject must use the balls in the lower display to copy the pattern shown in the upper display. The balls can be moved one at a time by touching the required ball, then touching the position to which it should be moved. At first it is only necessary to move one ball, but later on, up to four balls have to be moved. Afterwards, a procedure controlling for motor performance is inserted: the upper display moves one ball at a time, repeating the moves made by the subject in the corresponding previous planning phase and the subject must follow the upper display by moving the balls in the lower display. A second block of planning problems of two, four and five moves then follows. The test is completed with a second block of matching motor control problems.

Figure 4-4: screenshot of the SOC

Two SOC outcome measures were selected for this study: problems solved in minimum moves and mean moves for n-move problems. The first one is a fundamental measure, recording the number of

occasions upon which the subject has successfully completed a test problem in the minimum possible number of moves. This is a measure of overall planning accuracy. The second measure describes the mean number of moves required by the subject to solve problems with solutions possible in two, three, four or five moves.

Intra-/extradimensional shift (IED; clinical mode) is a test of rule acquisition and reversal and as such, also reflects cognitive flexibility (Downes, Roberts, Sahakian, Evenden, Morris and Robbins, 1989). It takes around seven minutes to administer. It is a computerized analogue to the Wisconsin Card Sorting Test. The computer screen shows four squares, two of them empty, two of them filled with stimuli. These are either simple stimuli, made up of just one dimension (color-filled shapes), or compound stimuli, made up of two dimensions (color-filled shapes and white lines; see Figure 4-5). The subject starts by looking at simple color-filled shapes and must learn which one is correct by touching one of them. Feedback teaches the subject which one is correct, and after six correct responses, the stimuli and/or rules are changed. These shifts are initially intra-dimensional (color filled shapes remain the relevant dimension), then later extra-dimensional (white lines become the relevant dimension). There are nine stages to be completed. Subjects completing all nine stages are considered to have 'passed the test'.

Figure 4-5: screenshot of the IED

Four IED outcome measures were selected for this study: two scores for the number of stages/trials completed and two error-scores. The stages completed score consists of the total number of stages completed successfully. The total trials (adjusted) score consists of the total number of trials completed on all attempted stages, with an adjustment for any stages

not reached. Furthermore, one error-score reflects the total number of errors made in blocks 2, 5, 7 and 9. These errors provide a good measure of reversal learning. The other error-score reflects the total number of errors made in blocks 6 and 8. These errors are a measure of attentional flexibility.

As well as the neuropsychological assessment with the CANTAB testing battery, a traditional paper and pencil test was conducted in order to obtain a measure of non-verbal fluency. The five point test (FPT), designed by Regard (1982), with a three-minute-limit (Lee, Strauss, Loring, McCLoskey and Haworth, 1997) and adapted for Dutch by Parigger (2006), measures non-verbal fluency. The FPT provides the subject with a sheet of paper showing eight rows of five squares. Within each of these squares, five points are depicted, just like the eyes on a dice. The purpose of the test is to make as many designs as possible by connecting the dots with lines. Between two points, only one line is allowed and only straight lines are permitted. Furthermore, the subject is told to only draw unique designs, that is, not to repeat designs already made. Two scores are of interest in the FPT, both derived from the raw score: the percentage of unique designs, and the percentage of repeated designs (perseverations). The higher the percentage of unique designs and the lower the percentage of perseverations, the more fluent subjects are supposed to be in their non-verbal responses.

4.5 Statistics

This section will first give an overview of the data collected in this study (Section 4.5.1). Moreover, the statistical analyses that were used will be explained (Section 4.5.2). The section also addresses the issue of interrater reliability (Section 4.5.3).

4.5.1 (Missing) data

Table 4-8 gives an overview of all available data in the ADHD group, the SLI group and the TD group.

Of the possible 938 datasets (14 different tasks/tests from 67 different children), 921 datasets (98.2%) could actually be collected. Of the missing 17 datasets (1.8%), the largest part is due to parents of SLI children failing to return questionnaires (three background questionnaires; five CCC-2-NL questionnaires; five VVGK questionnaires).

	ADHD (n=26)	SLI (n=19)	TD (n=22)	Total (n=67)
Questionnaires				
Background (general information)	26	16	22	64
CCC-2-NL ([pragmatic] language)	26	14	22	62
VVGK (externalizing behavior)	26	14	22	62
Language assessment				
Frog story (narration)	26	19	22	67
NWR (non-word repetition)	26	19	22	67
ZIT (sentence imitation)	26	19	22	67
RWT/PWT ([non]word reading)	26	19	22	67
Neuropsychological assessment				
SON-R (intelligence)	26	19	22	67
SST (inhibition)	23	19	22	64
SWM (working memory)	26	19	22	67
SOC (planning)	25	19	22	66
IED (cognitive flexibility)	26	19	22	67
FPT (non-verbal fluency)	26	19	22	67

Table 4-8: overview of data obtained from the ADHD, SLI and TD groups

Also, from the CANTAB data, one SOC result is missing, due to software errors, from an ADHD child. Furthermore, three SST results are missing, all from ADHD children, since they failed to complete the task. The statistical analyses in Chapters 5, 6 and 7 were thus sometimes performed on fewer than the maximum of 67 children, but never on less than 62 children.

4.5.2 *Statistical analyses*

All data were entered into and analyzed with the statistical program SPSS (see Field, 2005).

The data were checked as to whether they were normally distributed, and had homogeneous variances. If the data were not normally distributed, as indicated by a Kolmogorov-Smirnov test, parametric tests were nevertheless used, but, where possible, checked with a non-parametric test. In case of disagreement between the two statistical tests, only the non-parametric test result was reported. In case of unequal variances, as indicated by Levene's test, Welch F was reported. Some further checks were made for specific statistical tests. These included Mauchly's test for sphericity when conducting a repeated measures ANOVA (when significant followed by the Greenhouse-Geisser correction), and Box's test for equality of covariance matrices when conducting a MANOVA.

Null-hypotheses are rejected or accepted, depending on the p-values of the particular statistical tests. In this study, type I (i.e 'false positive') and type II (i.e. 'false negative') errors were considered to be equally undesirable. Therefore, a fairly standard p-value of .05 was adhered to. Furthermore, effect sizes were reported. In case of parametric testing, this usually was the η_p^2. In case of non-parametric testing, it usually was Cohens' d. Cohen (1992) considers an effect size of .2 to be small, of .5 to be medium, and of .8 to be large.

The dependent measures were analyzed using ANOVAs with group (three levels)[33] as the between subject factor. When for one task there was more than one dependent variable, MANOVAs were used instead of ANOVAs. We co-varied IQ scores, because the scores of the groups differed, and intelligence can potentially be related to the outcome measures that were used. When necessary, outliers were removed from the data. This was never done without mention. Furthermore, planned comparisons were applied. With planned comparisons, contrasts between groups can be tested statistically. In this study, simple (last) and difference contrasts were used.
Explorative correlations were also carried out. We opted for partial correlations, to control for the differences in IQ-scores.

Additionally, within-group and individual comparisons were made. This was normally done to compare various outcome measures and in order to do so, scores were converted to z-scores, with a mean of 0 and a SD of 1.

In case of multiple comparisons, Holm's correction was applied to make sure that the chance for a Type I error did not exceed the .05 level. In fact, Holm's correction is very much like a Bonferroni correction, but somewhat less conservative. The *p*-values of the relevant tests are ordered from the smallest to the largest. The smallest *p*-value needs to be smaller or equal to α/k (α is .05 and k is the number of tests). The next smallest *p*-value needs to be smaller than $\alpha/k-1$ and so on, until the corrected *p*-value becomes larger than .05 (Holm, 1979).

4.5.3 Interrater reliability

As is clear from Table 4-8, three different sets of data were collected in this study: (1) data from the questionnaires, (2) data from the

[33] However, when testing four groups, the Kruskall-Wallis test was performed. This is the non-parametric counterpart of an ANOVA. See for example Section 5.7 where two ADHD groups (one with and one without language problems), the SLI group and the TD group are compared.

language assessment and (3) data from the neuropsychological assessment.

An interrater reliability estimate was not needed for the data gathered from the questionnaires. Answers to questionnaires are normally not subject to many interpretational problems. The researcher put the answers to the questions into the statistical program SPSS. This was double checked by one of the interns, who all had a background in clinical linguistics, in order to eliminate mistakes. An interrater reliability estimate was also not needed for data from the neuropsychological assessment, because the CANTAB battery automatically computes all outcome measures. This is a standardized procedure, so that mistakes cannot occur.

The data from the language assessment are susceptible to error. This was dealt with in two ways. The sentence imitation task, the non-word repetition task and the (non-)word reading tasks were coded both by the researcher and by one of the interns. All coding inconsistencies were then resolved. The frog story was transcribed by one of the interns and checked by another intern. The researcher herself checked the transcripts for a third time and eliminated a few last minor errors. The coding of the frog story transcripts was done by the researcher herself. An intern also coded a random 10% of the transcripts of each of the three groups to be able to determine the interrater reliability. Interrater reliability in this study was defined as the percentage of agreement between the two coders. In general, the interrater reliability over all coding categories was good. More specifically, agreement was 90% for the grammatical outcome measures and 89% for the pragmatic outcome measures.

5

Results of language measures

The overall aim of this chapter is to answer to the first of the three research questions about language production in children with ADHD, compared to SLI and TD children (see Sections 2.4 and 3.4).

Frog story (narration)	Outcome measures
General	number of analyzable T-units, total number of utterances not related to the story, total number of non-analyzable utterances, mean length of utterance (in words), percentage of subordinate conjunctions, percentage of dysfluencies, percentage of direct speech
Grammar	percentage of morpho-syntactic errors, percentage of morphological errors, percentage of syntactic errors, percentage of clustered morpho-syntactic errors
Pragmatics	total number of plot elements, total number of setting elements, total number of initiating events, total number of internal responses, total number of search attempts, total number of goals

Table 5-1 (copy of Table 4-4): overview of outcome measures, subdivided in general, grammatical and pragmatic measures, in narrative task (frog story) used in language assessment

Language tasks and questionnaire	Outcome measures
ZIT	number of items correct (out of 20)
NWR	number of items correct (out of 16), percentage of phonemes repeated correctly
CCC-II-NL	scales (10x): speech production, syntax, semantics, coherence, inappropriate initiation, stereotyped language, use of context, non-verbal communication, social relations, interests
	composites (3x): general communication score, social interaction score, pragmatic score

Table 5-2 (copy of Table 4-5): overview of outcome measures in repetition tasks (sentence imitation task [ZIT] and non-word repetition task [NWR]) and language questionnaire [CCC-II-NL] used in language assessment

To answer this question, different language measures were used (see Section 4.3). Table 4-4 and Table 4-5 gave an overview of the (outcome) measures in the language assessment. These tables are repeated above, for convenience.

In Section 3.4, the expectation was formulated that SLI children should show more grammatical language problems than ADHD children and TD children. ADHD children are not expected to differ from TD children on grammatical outcome measures (SLI<ADHD=TD). In the case of pragmatics, we expect ADHD children to have more problems than TD children, but not necessarily more than SLI children. Furthermore, SLI children are expected to have lower scores than TD children on the pragmatic outcome measures (ADHD<SLI<TD or ADHD=SLI<TD).

The results of the narrative task will be presented in Section 5.1, the sentence imitation task in Section 5.2, the non-word repetition task in Section 5.3 and the language questionnaire in Section 5.4.

The relation between the linguistic findings will be discussed in Section 5.5, Section 5.6 and Section 5.7. Finally, in Section 5.8, a summary will be presented.

5.1 Narrative task

This section will regularly refer to the study by Blankenstijn and Scheper (2003 - also see Section 2.2.2). This study is often the only point of reference when discussing many of the variables, and the sample used in this study. Blankestijn and Scheper performed linguistic analyses on conversations and narratives of Dutch 4- to 9-year-old children with psychiatric impairments (n=120), including children with ADHD (n=19), and compared these to the analyses of typically developing children (n=75). One of their main results was that the vast majority of the psychiatrically impaired children have problems with grammatical and/or pragmatic aspects of language. Unfortunately, Blankenstijn and Scheper did not present separate data for the ADHD children in their sample of psychiatrically impaired children. Moreover, they did not include SLI children in their study.

5.1.1 General outcome measures of the narrative

Table 5-3 shows the mean score (with the SD between brackets) for each of the general outcome measures in the three groups.

There are seven general outcome measures (see Section 4.3.1). The total number of analyzable T-units in the narrative is presented. The utterances not related to the story are counted separately, as are the non-analyzable utterances. The mean length of utterance, the percentage of subordinate conjunctions and the percentage of direct speech are all considered to reflect, albeit in a different manner, the complexity of the analyzable T-units. Finally, the percentage of dysfluencies as a reflection of the ability to formulate a narrative fluently is presented too.

Frog story General measures	SLI (n=19)	ADHD (n=26)	TD (n=22)	Contrasts
Number of analyzable T-units	43.84 (11.77)	45.42 (13.34)	44.91 (11.47)	ns
Utterances not related to story	2.68 (2.08)	2.19 (3.67)	1.09 (1.34)	ns
Non-analyzable utterances	5.21 (3.84)	4.15 (2.48)	2.50 (1.90)	SLI=ADHD>TD
Mean length of utterance - words	5.80 (.91)	6.39 (1.08)	7.13 (.91)	SLI<ADHD<TD
Subordinate conjunctions (%)	3.16 (3.90)	4.39 (4.58)	5.16 (4.39)	ns
Direct speech (%)	8.32 (4.88)	9.51 (14.45)	4.70 (5.68)	ns
Dysfluencies (%)	36.05 (29.07)	26.03 (21.29)	34.27 (14.46)	ns

Table 5-3: general outcome measures of the frog story in means and SD (between brackets) for SLI, ADHD and TD groups. Contrasts are reported in the last column

Despite a significant overall group effect for the seven dependent general variables of the frog story, Wilks' Λ=.597, $F(14, 116)=2.44$, $p<.05$, $\eta_p^2=.23$, subsequent ANOVAs with Holm's correction only reveal significant group effects for two variables: mean length of utterance in words, $F(2, 64)=9.52$, $p<.05$, $\eta_p^2=.23$, and non-analyzable utterances, $F(2, 64)=5.02$, $p<.05$, $\eta_p^2=.14$. The significant contrasts are shown in Table 5-3. The MANCOVA co-varying for non-verbal IQ produces the same results.

Five general frog story measures show no significant differences (Table 5-3). The length of the narratives, as measured in T-units, does not vary. The same is true for the number of utterances not related to the story. These results fit with the findings by Blankenstijn and Scheper (2003). Looking at the raw scores of the variables percentage of subordinate conjunctions and percentage of direct speech, we can see that the TD group performs best, and the SLI and

ADHD groups perform worse. However, the frequency of occurrence is low for both variables. ADHD children have a lower percentage of dysfluencies than SLI and TD children – at least in terms of raw scores. This is in contrast to Redmond (2004), who found that 5- to 8-year-old ADHD children had a high percentage of mazed words, and a high average number of words per maze, as compared to SLI and TD children. However, he made use of conversational data, and the different findings might thus be due to the different tasks.

The ADHD children have a significantly higher mean length of utterance than the SLI children, but a significantly lower mean length of utterance than the TD children (Table 5-3). MLU in words was computed on the basis of the analyzable utterances only, and thus not confounded by the findings for the variable non-analyzable utterances[34]. From the literature, it is known that SLI children have a lower MLU in comparison with TD children (e.g. Klee, Schaffer, May, Membrino and Mougey, 1989). However, it is less clear from previous studies whether ADHD children also do. Redmond (2004), albeit in a study of conversations, found that ADHD children (5-8 years of age) had the same MLU as TD children, but that SLI children, compared to these two groups, had a lower MLU. In the present study, the results show that SLI children indeed have the lowest MLU. However, ADHD children were also significantly lower than TD children. This can perhaps be explained by the fact that a narrative task is used instead of a conversation. Zentall's (1983; 1988) results with 9-year-old hyperactive children suggest that these children produce shorter narratives in non-structured elicited tasks. The frog story is an elicited language task, and quite unstructured.

[34] When we do take these non-analyzable utterances into account, the means and SD remain more or less the same for all three groups (mean score ADHD: 6.03 (SD 1.08)); mean score SLI: 5.75 (SD .94); mean score TD: 7.03 (SD 1.04). The ANOVA also shows a overall difference, $F(2, 64)=9.22$, $p<.05$, $\eta_p^2=.22$. However, in this case, the significant contrasts are different: SLI=ADHD<TD.

This language problem in ADHD children might then only show up in specific tasks.

The variable non-analyzable utterances also shows a significant contrast. As expected, the SLI children produce the most non-analyzable utterances and the TD children the fewest (Table 5-3). Furthermore, the ADHD children produce as many non-analyzable utterances as the SLI children, indicating a language problem here.

5.1.2 Grammatical outcome measures of the narrative

The four grammatical measures are based on a grammatical error-analysis carried out with the STAP method (Van den Dungen and Verbeek, 1999; see Table 5-4). It distinguishes morphological errors and syntactic errors. The outcome measure morpho-syntactic errors is the sum of the morphological errors and the syntactic errors. Finally, clustered errors are defined as the occurrence of two or more morphological and/or syntactic errors in one T-unit (see Section 4.3.1 for further details of the method).

There is a significant main effect of group for the four dependent grammatical variables of the frog story, Wilks' Λ=.483, $F(6, 124)=9.08$, $p<.05$, $\eta_p^2=.31$.

Subsequent ANOVAs with Holm's correction show significant effects of group for percentage of morpho-syntactic errors, $F(2,64)=27.36$, $p<.05$, $\eta_p^2=.46$, percentage of morphological errors, $F(2,64)=16.78$, $p<.05$, $\eta_p^2=.34$, percentage of syntactic errors $F(2, 64)=18.53$, $p<.05$, $\eta_p^2=.37$ and percentage of clustered morpho-syntactic errors. The significant contrasts are presented in Table 5-4. Controlling for non-verbal IQ with a MANCOVA does not alter the results.

From Table 5-4 it is clear that the SLI children make significantly more errors than both the ADHD and the TD children. As described in Section 4.1.2, the presence of grammatical problems was one of the main criteria for the selection of children in the SLI group.

Therefore, this finding was expected. The fact that the ADHD group does not make more grammatical errors than the TD children is not surprising on the basis of the literature (see expectations formulated in Section 3.4).

Frog story **Grammatical measures**	**SLI** **(n=19)**	**ADHD** **(n=26)**	**TD** **(n=22)**	**Contrasts**
Morpho-syntactic errors (%)	63.91 (35.35)	22.62 (15.28)	17.96 (9.77)	SLI>ADHD=TD
Morphological errors (%)	15.15 (9.47)	4.88 (5.49)	5.11 (3.71)	SLI>ADHD=TD
Syntactic errors (%)	48.81 (33.66)	17.73 (13.81)	12.85 (8.22)	SLI>ADHD=TD
Clustered errors (%)	14.62 (14.21)	3.12 (3.34)	1.75 (1.92)	SLI>ADHD=TD

Table 5-4: grammatical outcome measures of the frog story in means and SD (between brackets) for SLI, ADHD and TD groups. Contrasts are reported in the last column

5.1.3 Pragmatic outcome measures of the narrative

The plot analysis involves six measures (see Table 5-5). The main emphasis is on the production of narrative events, the so-called planning or plot components. A total of 19 plot components is distinguished and divided into five categories (also see Section 4.3.1 and, in particular, Table 4-6). In order to narrate a coherent story, it is necessary to produce most or all of the plot components. The development of this narrative ability develops past the age of nine (Roelofs, 1998; Blankenstijn and Scheper, 2003).

A marginally significant overall effect for group is found for the six dependent plot analysis variables, Wilks' Λ=.762, $F(10, 120)=1.75$, $p=.08$, $\eta_p^2=.13$. However, subsequent ANOVAs with Holm's correction only show a significant group effect for setting elements, $F(2, 64)=6.35$, $p<.05$, $\eta_p^2=.17$ (see Table 5-5). The MANCOVA controlling for non-verbal IQ produces the same results.

Frog story **Plot analysis measures**	**SLI** **(n=19)**	**ADHD** **(n=26)**	**TD** **(n=22)**	**Contrasts**
Plot elements (total=19)	8.37 (3.83)	9.19 (3.56)	11.14 (3.21)	ns
Setting elements (2)	1.05 (.78)	1.19 (.69)	1.73 (.46)	SLI=ADHD<TD
Initiating events (6)	2.74 (1.28)	3.15 (1.22)	3.45 (1.30)	ns
Internal responses (2)	.00 (.00)	.12 (.33)	.09 (.29)	ns
Search attempts (7)	3.68 (2.16)	3.81 (2.10)	4.64 (1.68)	ns
Outcome (2)	.89 (.81)	.92 (.80)	1.23 (.75)	ns

Table 5-5: plot analysis outcome measures of the frog story in means and SD (between brackets) for SLI, ADHD and TD groups. Contrasts are reported in the last column

In terms of raw scores (Table 5-5), the order between the three groups is fairly consistent, with the TD children having the highest, the SLI children having the lowest and the ADHD children scoring in between. However, this finding is, with one exception, not reflected in the statistical results, probably due to the rather large variation in scores[35]. Furthermore, the two internal responses, being sad and being happy, are almost never formulated explicitly by any of the children in this study. This is in line with Blankenstijn and Scheper's (2003) findings.

The only clear statistical difference is in the category of setting elements. Within this category, two plot elements are distinguished:

[35] Without Holm's correction (see Section 4.5.2), the group effect for the dependent variable total number of plot elements is significant too, $F(2, 64)=3.42$, $p=.039$, $\eta_p^2=.10$; SLI=ADHD<TD (see Table 5-5). This fits with Blankenstijn and Scheper's (2003) finding that psychiatrically impaired children produced a lower number of plot elements than typically developing children. The uncorrected result in this analysis is mentioned here, because it at least teaches us that problems in this area cannot too readily be dismissed.

(1) introduction of boy, dog and frog, and (2) boy possesses frog. Table 5-6 displays the figures for these two setting elements.

Frog story Setting elements (subdivision)	**SLI (n=19)**	**ADHD (n=26)**	**TD (n=22)**	**Contrasts**
Introduction of boy, dog and frog	.58 (.51)	.85 (.37)	.86 (.35)	SLI<ADHD=TD
Boy possesses frog	.47 (.51)	.35 (.49)	.86 (.35)	SLI=ADHD<TD

Table 5-6: subdivision of setting elements of the frog story in means and SD (between brackets) for SLI, ADHD and TD groups. Contrasts are reported in the last column

There is a nearly significant difference between the three groups on the first setting variable, $F(2, 64)=3.121$, $p=.051$, $\eta_p^2=.08$. The ADHD and TD groups have more or less equal scores. This is also what Blankenstijn and Scheper (2003) found, when comparing their group of psychiatrically impaired children with their group of typically developing children. The SLI group performs below the scores of the ADHD and TD groups. For the second setting variable, we find a significant difference between the three groups, $F(2, 64)=8.125$, $p<.05$, $\eta_p^2=.20$. The ADHD and SLI groups have lower scores than the TD group. The two clinical groups expressed the boy's possession of the frog far less often. This is important later on in the story in order to understand why the boy is motivated to search for the frog. Blankenstijn and Scheper (2003) also found that their psychiatrically impaired children only started to produce this element at eight or nine years of age. Their TD children were also late, showing an increased production of this setting element between seven and eight years of age. The TD children in this study are slightly older and, unlike the ADHD and SLI children, generally express the possessive relation between the boy and the frog.

There was no significant difference on the variable search attempts (see Table 5-5). However, a closer examination of the structure of the search attempts shows some interesting trends, which will be reported separately.

As explained in Section 4.3.1, a search attempt is scored when the subject and the verb expressing the search are produced.
This so-called state of affairs may or may not be followed by a location (for example in the room) and a goal (for example the frog). Additionally, the outcome of the search attempt may or may not be explicitly related. As such, the category of search attempts is a composite measure (Blankenstijn and Scheper, 2003).

Frog story Subdivision in search attempts (7)	**SLI (n=19)**	**ADHD (n=26)**	**TD (n=22)**
+SA, -loc., -goal, -outcome	1.05 (1.43)	.85 (1.01)	.41 (.50)
+SA, +loc., +/-goal, +/-outcome	1.68 (1.67)	2.31 (1.74)	3.55 (1.74)
+SA, +/-loc., +goal, +/-outcome	1.05 (1.35)	1.23 (1.34)	1.82 (1.50)
+SA, +/-loc., +/-goal, +outcome	1.26 (1.05)	1.27 (1.19)	2.09 (1.38)
+SA, +loc., +goal, +outcome (GAO)	.32 (.75)	.46 (.71)	.90 (.97)

Table 5-7: subdivision of the seven search attempt elements of the frog story in means and SD (between brackets) for SLI, ADHD and TD groups. MANOVA not significant, Wilks' Λ=.777, $F(10, 120)=1.612$, $p>.05$, $\eta_p^2=.12$

Looking at the raw figures in Table 5-7[36], we see that both ADHD and SLI children articulate more search attempts consisting solely of

[36] The totals in Table 5-5 are lower than the totals in Table 5-7. This is because some of the search attempts were counted more than once, to provide information for different analyses. For example, when a state of affairs was coded with a location and a goal, but without an outcome (coded as +SA, +loc., +goal, -outcome), this was added to the totals of both the second and the third analyses.

a state of affairs. TD children make more use of the other possibilities. That is, they tend to make more complex search attempts. As already pointed out, the most sophisticated way to express a search attempt is to produce it as a goal-action-outcome unit (GAO-unit; Trabasso and Nickels, 1992). These units can be seen as mini-plots on their own, within the overall plot of the frog story. Complete productions show that the speaker is able to take the listener's perspective into account by adding the extra information that the listener needs to fully understand the various search attempts. Blankenstijn and Scheper (2003) found that only a few of their typically developing children and even fewer psychiatrically impaired children were able to do this in an adult-like way. They find that the major progress in this area is made after the age of 8 or 9. This is confirmed in this study. The number of complete GAO-units produced by the ADHD, SLI and TD children was very low, although the TD children seemed to do better than both the ADHD and the SLI children.

5.1.4 Interim summary on narrative task measures

For the narrative variables that showed significant differences, the SLI group always had lower scores than the TD children. The ADHD children were worse than the TD children on only a relative few of the narrative variables: number of non-analyzable utterances, number of setting elements and MLU in words. They were equal to the SLI children on the first two, and fell in between the SLI and TD group on the third one. Examination of the raw scores indicated that these patterns were common also in variables that showed no significant group differences. It is the question whether this implies that the language problems of ADHD are generally less severe, or whether specific individuals show language problems. This issue will be returned to in Section 5.7.

5.2 Sentence imitation task

Significant group differences emerge from the ANOVA for the one dependent measure, the number of items repeated correctly, on the sentence imitation task (also see Section 4.3.2 and Table 4-5), $F(2, 64)=31.42$, $p<.05$, $\eta_p^2=.50$. The significant contrast is reported in Table 5-8. The ANCOVA with non-verbal IQ as a covariate reveals the same pattern of results.

ZIT	SLI (n=19)	ADHD (n=26)	TD (n=22)	Contrasts
Items repeated correctly (out of 20)	9.00 (4.47)	15.88 (3.80)	17.18 (1.89)	SLI<ADHD=TD

Table 5-8: outcome measure (number of items repeated correctly, out of 20) of the sentence imitation task (ZIT) in means and SD (between brackets) for SLI, ADHD and TD groups. The contrast is reported in the last column

The SLI group clearly repeats fewer items correctly than both the ADHD and the TD group. This was expected on the basis of the literature (see Section 2.1.2). The ADHD group and the TD group do not differ significantly from each other. This was not as expected (Section 2.2.2).

Moreover, as already mentioned in Section 4.3.2, additional qualitative analyses on the error categories of this sentence imitation task were performed by Dijkhuizen (2010). This study showed that errors in the agreement marking on the main verb and ungrammatical omissions of the determiners were typical of the SLI group. However, no error categories were found to characterize the group of ADHD children, not even for those ADHD children that scored below the clinical cut-off point of the task.

The repetition of sentences yields data for evaluating the level of children's linguistic proficiency, in particular their grammatical proficiency. Apparently, children with ADHD do not experience

grammatical problems as measured with the sentence imitation task in this study.

5.3 Non-word repetition task

There is a significant main effect of group for the two dependent non-word repetition variables (also see 4.3.2 and Table 5-2), Wilks' Λ=.777, $F(4, 126)=4.24$, $p<.05$, $\eta_p^2=.12$[37]. Subsequent ANOVAs with Holm's correction show significant effects of group for number of items repeated correctly, $F(2, 64)=6.06$, $p<.05$, $\eta_p^2=.16$ and percentage of phonemes repeated correctly, $F(2, 64)=4.51$, $p<.05$, $\eta_p^2=.12$. The significant contrasts are presented in Table 5-9. Controlling for non-verbal IQ with a MANCOVA does not alter the results.

NWR	**SLI (n=19)**	**ADHD (n=26)**	**TD (n=22)**	**Contrasts**
Items repeated correctly (out of 16)	4.32 (2.54)	6.88 (2.16)	6.23 (2.79)	SLI<ADHD=TD
Phonemes repeated correctly (%)	68.59 (13.51)	76.89 (12.20)	79.40 (10.14)	SLI<TD

Table 5-9: outcome measures (number of items repeated correctly, out of 16; percentage of phonemes repeated correctly) of the non-word repetition task (NWR) in means and SD (between brackets) for SLI, ADHD and TD groups. Contrasts are reported in the last column

The SLI group repeats fewer items correctly than both the ADHD and the TD group. Furthermore, the SLI group has lower scores than the TD group on percentage of phonemes repeated correctly. The ADHD group does not differ from the SLI group on the one hand and the TD group on the other hand. As mentioned in Section 2.1.2, the non-word repetition task measures phonological memory, and deficits in

[37] However, this result has to be interpreted cautiously, because Box's test of equality of covariance matrices turned out to be significant (see Section 4.5.2).

phonological memory affect both lexical learning and comprehension of grammar. These in turn can explain problems with complex grammar. Previous studies indicated that SLI children have difficulties with the non-word repetition task (see Section 2.1.2), but ADHD children do not (see Section 2.4). The results of the non-word repetition task in this study are therefore as expected.

5.4 Language questionnaire

The CCC-II-NL measures the child's general language use, focusing in particular on pragmatics. The primary goal of this questionnaire is to obtain information on a broad range of pragmatic variables that supplements the more in-depth pragmatic analyses of the language samples (see Sections 4.3.1 and 5.1.3). An additional advantage is that it offers a different perspective on the pragmatic skills of the children, since it is filled in by their parents, and not by the researcher. Information on various other aspects of language, for example phonology, syntax and semantics is also collected with the help of this questionnaire. The CCC-II-NL contains 10 scale scores and three composite scores.

The results are reported in Table 5-10. When interpreting the findings, it is important to keep in mind that high scores signal low performance. That is, a child with a high score performs worse than a child with a low score on a particular scale or composite of the CCC-II-NL. So, for example, on the scale speech production the SLI children are performing worse than ADHD children, and they in turn perform worse than TD children.

A significant overall group effect is found for the 10 dependent scale score variables, Wilks' Λ=.346, $F(20, 100)=3.50$, $p<.05$, $\eta_p^2=.41$. Subsequent ANOVAs with Holm's correction reveal significant group effects for speech perception, $F(2, 59)=13.21$, $p<.05$, $\eta_p^2=.31$, for syntax, $F(2, 59)=20.71$, $p<.05$, $\eta_p^2=.41$, for semantics, $F(2, 59)=12.92$,

$p<.05$, $\eta_p^2=.31$, for coherence, $F(2, 59)=15.34$, $p<.05$, $\eta_p^2=.34$, for inappropriate initiation, $F(2, 59)=17.64$, $p<.05$, $\eta_p^2=.37$, for stereotyped language, $F(2, 59)=9.03$, $p<.05$, $\eta_p^2=.23$, for use of context, $F(2, 59)=15.45$, $p<.05$, $\eta_p^2=.34$, for non-verbal communication, $F(2, 59)=9.66$, $p<.05$, $\eta_p^2=.25$, for social relations, $F(2, 59)=6.412$, $p<.05$, $\eta_p^2=.18$, and for social interests, $F(2, 59)=4.791$, $p<.05$, $\eta_p^2=.14$. The significant contrasts are presented in Table 5-10. The MANCOVA with non-verbal IQ as covariate reveals the same pattern of results.

In the remainder of this section, the findings for the scale scores will first be discussed, followed by a discussion of the composite scores. The SLI group has worse scores than the TD group on all variables. On seven individual scales, the SLI and ADHD group are not significantly different, both being worse than the TD group. On the speech production and syntax scales, the SLI group scores worse than the ADHD group and the ADHD group in turn scores worse than the TD group. On only one variable, the inappropriate initiation scale, does the ADHD group score the worst.

This result could be expected on the basis of the diagnosis. The impulsivity symptom cluster in an ADHD diagnosis (Section 2.2.1), very much resembles the inappropriate initiation scale (for example 'often blurts out the answer before questions have been completed', and 'often has difficulty awaiting turn').
The finding that the SLI group and the ADHD group are comparable on seven variables (semantics, coherence, stereotyped language, context, non-verbal communication, social relations and interests) clearly shows that the ADHD children as a group have problems in specific areas of language, including pragmatics.

A significant overall effect for group is also found for the three dependent composite score variables, Wilks' $\Lambda=.414$, $F(6, 114)=10.526$, $p<.05$, $\eta_p^2=.36$.

CCC-II-NL	SLI (n=14)	ADHD (n=26)	TD (n=22)	Contrasts
Scale speech production	16.00 (2.57)	12.58 (3.90)	10.31 (2.68)	SLI>ADHD>TD
Scale syntax	15.21 (2.08)	11.80 (3.16)	9.23 (2.51)	SLI>ADHD>TD
Scale semantics	13.29 (1.90)	12.35 (2.51)	9.32 (2.92)	SLI=ADHD>TD
Scale coherence	14.14 (2.25)	13.00 (2.67)	9.82 (2.48)	SLI=ADHD>TD
Scale inappropriate initiation	11.36 (1.95)	13.27 1.78	9.50 (2.72)	ADHD>SLI>TD
Scale stereotyped language	12.64 (2.92)	11.88 (2.75)	8.95 (3.02)	SLI=ADHD>TD
Scale context	13.50 (2.07)	13.27 (2.86)	9.36 (2.85)	SLI=ADHD>TD
Scale non-verbal communication	12.64 (2.37)	12.81 (2.50)	9.86 (2.51)	SLI=ADHD>TD
Scale social relations	11.50 (2.56)	12.62 (2.70)	9.68 (3.14)	SLI=ADHD>TD[a]
Scale interests	11.79 (2.26)	12.00 (2.08)	10.05 (2.55)	SLI=ADHD>TD
General communication composite	108.79 (12.52)	100.86 (15.28)	76,36 (15,76)	SLI>ADHD>TD
Pragmatics composite	50.14 (6.64)	51.23 (7.65)	37.68 (9.42)	SLI=ADHD>TD
Social interactions composite	-11,36 (4.83)	.96 (9.85)	.41 (7.64)	SLI<ADHD=TD

[a] SLI>TD is only marginally significant (*p*=.07)

Note that the SLI group (n=14) is smaller than usual (n=19), due to missing CCC-II-NL questionnaires (see Section 4.5.1)

Note that a high score means low performance (except for the social interaction composite; see Section 4.3.3)

Table 5-10: outcome measures of language questionnaire (CCC-II-NL) in means and SD (between brackets) for SLI, ADHD and TD groups. Contrasts are reported in the last column

Subsequent ANOVAs with Holm's correction show significant group effects for all three variables, for the general communication score, $F(2, 59)=25.15$, $p<.05$, $\eta_p^2=.46$, for the social interaction score, $F(2, 59)=11.80$, $p<.05$, $\eta_p^2=.29$, and for the pragmatic score, $F(2, 59)=18.69$, $p<.05$, $\eta_p^2=.39$. Again, controlling for non-verbal IQ in a MANCOVA does not alter the results.

A score above 104 for the general communication composite means that a child scores above the 90th percentile, and a score above 110 means that a child scores above the 95th percentile[38]. These high scores, signalling a low performance, are within the clinical range of the instrument. The SLI children as a group score in between the 90th and the 95th percentile. The ADHD children as a group fall just outside the clinical range, with scores between the 85th and the 90th percentile. The TD children as a group score better than both the SLI and the ADHD group, in the normal range, with a mean score between the 40th and the 45th percentile (see Table 5-10). The relatively bad performance of the SLI group and the relatively good performance of the TD group are as expected. The ADHD children as a group show up as having substantial problems in general communication. Their scores are just within the normal range, but are significantly different from the children in the TD group. The fact that pragmatic variables constitute an important part of the general communication score can account for this result. Problems with pragmatics were expected (see Section 3.4).

The cut-off for the pragmatic composite score is 53. Scores above 53 are indicative of scores above the 90th percentile, i.e. the clinical range. The TD group performs the best of the three groups, in the normal range, between the 35th and 40th percentile. The scores of both the SLI group and the ADHD group fall just outside the clinical

[38] The percentile equivalents for the general communication composite, the pragmatic composite and the social interaction composite can be found in the CCC-II-NL manual (Geurts, 2007).

range, being between the 80th and the 85th percentile for the SLI group and between the 85th and 90th percentile for the ADHD group (see Table 5-10). The difference between the two groups is not significant. These scores confirm the prediction that ADHD children have problems with pragmatics (see Section 3.4).

In comparison with the previous two composite scores, the social interaction score is used somewhat differently in the CCC-II-NL instrument (also see Section 4.3.3). It is normally used in research contexts to classify children, reflecting a differentiation between structural language problems on the one hand and pragmatic language problems, like the ones seen in autism spectrum disorders, on the other hand. Children with a low negative social interaction score will mainly have structural language problems. Children with a high positive social interaction score will mainly have pragmatic problems. As can be seen from Table 5-10, the ADHD group and the TD group score neither low nor high. However, the SLI group's scores are negative and lower than the scores of both the ADHD and the TD group. This indicates that structural language problems are salient. This is not surprising considering the fact that these kinds of problems form the basis of the diagnosis of SLI (see Section 2.1.1).

A further discussion of individual scores on the CCC-II-NL will be presented in Section 5.7.

5.5 Comparisons of the language measures

In the previous sections, we evaluated the performance of the ADHD, SLI and TD groups per language measure. Since the various outcome measures are difficult to compare directly, five of the most global measures were transformed into z-scores, with a mean of 0 and a SD of 1. These were the percentage of morpho-syntactic errors in the frog-story (OMS-%; Table 5-4), the total number of plot

elements in the frog-story (PE-number; Table 5-5), the pragmatic composite in the children's communication checklist (PC-CCC; Table 5-10), the items repeated correctly in the sentence imitation task (ZIT-correct; Table 5-8), and the items repeated correctly in the non-word repetition task (NWR-correct; Table 5-9).

Outcome measure	SLI ≤-1	SLI ≈0	SLI ≥+1	ADH ≤-1	ADH ≈0	ADH ≥+1	TD ≤-1	TD ≈0	TD ≥+1
OMS-%	53%	47%	0%	4%	92%	4%	0%	86%	14%
PE-number	16%	79%	5%	12%	88%	0%	5%	72%	23%
PC-CCC	7%	93%	0%	19%	77%	4%	0%	55%	45%
ZIT-correct	58%	42%	0%	8%	80%	12%	0%	100%	0%
NWR-correct	47%	53%	0%	4%	75%	23%	18%	59%	23%
Total	36%	63%	1%	9%	82%	9%	5%	74%	21%

Table 5-11: distribution of SLI (n=19; PC-CCC: 5 missing cases), ADHD (n=26), and TD (n=22) children across scoring categories on each of the language outcome measures. All outcome measures were transformed into z-scores (and reversed when necessary) to make comparisons possible. Scores less than 1 SD from the mean are considered to reflect normal performance (≈0) Scores equal to or more than 1 SD from the mean are considered to reflect a relatively bad (≤-1) or relatively good (≥+1) performance. Group performances are given in percentages, to correct for the different sample sizes

When necessary for correct interpretation, we also reversed the z-scores. Scores less than 1 SD from the mean were considered to reflect normal performance. Scores equal to or more than 1 SD from the mean were considered to reflect either bad (≤-1) or good (≥+1) performance. Group performances were calculated in percentages in order to correct for the different sample sizes. We used this information to evaluate within-group performance (Section 5.5.1) and individual performances (Section 5.5.2).

5.5.1 Within-group comparisons

Table 5-11 displays the results of the five outcomes for the ADHD, SLI and TD children. All three groups are divided in groups with bad, normal or good performance as defined above.

More SLI children (36%) fall into the subgroup displaying a bad performance compared to the ADHD and TD children. More TD children (21%) fall into the category with good performance. ADHD children's scores fall in between. Looking at the individual outcome measures, it is apparent that the phonological (NWR-correct) and grammatical tasks (OMS-% and ZIT-correct) are particularly difficult for the SLI children. The pragmatic tasks (PE-number and PC-CCC) are difficult for both the SLI and the ADHD children. The PC-CCC is particularly difficult for the ADHD children with 19% in the category with bad performance. These findings reflect the results discussed in Sections 5.1 to 5.4.

In sum, the results on these five global outcome measures indicate that ADHD children are different from TD children and again from SLI children. In the following section, the individual variation in scores will be explored.

5.5.2 Individual comparisons

In order to explore possible clustering of problems in individual children, Table 5-12 displays the results of the individual performances of the ADHD, SLI and TD children on the five selected global outcomes (see Section 5.5.1).

The table should be read as follows: the score '2-1' for the individual SLI1, in the first column, means that this particular child had two out of five scores equal to or more than 1 SD below the mean. That is to say, he performed poorly on two of the selected outcome measures.

Group +nr.	Nr. ≤-1	Nr. ≥+1	Group +nr.	Nr. ≤-1	Nr. ≥+1	Group +nr.	Nr. ≤-1	Nr. ≥+1
SLI1	2	1	ADH1	0	0	TD1	0	1
SLI2	2	0	ADH2	1	0	TD2	0	3
SLI3	1	0	ADH3	2	1	TD3	0	1
SLI4	3	0	ADH4	0	1	TD4	1	0
SLI5	2	0	ADH5	0	2	TD5	0	0
SLI6	2	0	ADH6	0	2	TD6	0	3
SLI7	0	0	ADH7	0	0	TD7	1	2
SLI8	4	0	ADH8	0	0	TD8	0	2
SLI9	0	0	ADH9	0	0	TD9	0	1
SLI10	0	0	ADH10	4	0	TD10	0	0
SLI11	4	0	ADH11	1	1	TD11	0	0
SLI12	2	0	ADH12	1	0	TD12	0	1
SLI13	3	0	ADH13	2	0	TD13	0	0
SLI14	4	0	ADH14	0	0	TD14	1	1
SLI15	1	0	ADH15	0	1	TD15	1	1
SLI16	2	0	ADH16	0	0	TD16	0	1
SLI17	2	0	ADH17	0	0	TD17	0	1
SLI18	0	0	ADH18	0	0	TD18	1	0
SLI19	0	0	ADH19	0	1	TD19	0	3
			ADH20	0	0	TD20	0	1
			ADH21	0	0	TD21	0	1
			ADH22	0	1	TD22	0	0
			ADH23	1	0			
			ADH24	1	1			
			ADH25	0	0			
			ADH26	0	0			

Table 5-12: overview of scores of individual SLI (n=19), ADHD (n=26), and TD (n=22) children. In each column, the scores reflect poor (left-hand side) versus good (right-hand side) performance, based on counts of z-scores being equal to or more than 1 SD from the mean. This is counted over the five most important outcome measures (cf. Table 5-11)

The same child had one out of five scores equal to or above 1 SD from the mean, thus performing relatively well on one of the selected outcome measures. By implication, the other two scores were in the normal range.

Table 5-13, derived from the figures in Table 5-12 (which will therefore not be further discussed), shows the percentage of children in the ADHD, SLI and TD groups that score equal to or more than 1 SD below the mean, that is, have a bad performance on either none of the five global outcomes, on one or two outcomes, or on three or more outcomes.

The same options are also displayed for the scores that are equal to or more than 1 SD above the mean. Thus, for example, the upper left cell reporting figures for the SLI group shows that 26% of the SLI children do not perform below average on any task. On the other hand, 48% perform below average on one or two tasks, and the remaining 26% are below average on more than three tasks.

Scores	**SLI 0**	**SLI 1-2**	**SLI 3-5**	**ADH 0**	**ADH 1-2**	**ADH 3-5**	**TD 0**	**TD 1-2**	**TD 3-5**
≤-1SD from mean	26%	48%	26%	69%	27%	4%	77%	23%	0%
≥+1SD from mean	95%	5%	0%	65%	35%	0%	32%	54%	14%

Table 5-13: percentage of SLI (n=19), ADHD (n=26) and TD (n=22) children that score, respectively, 0/5, 1-2/5 or 3-5/5 times ≤-1 SD from the mean, and, likewise, ≥+1 SD from the mean

It is clear that the majority of SLI children have poor scores, although 26% fall in the normal range on all tasks. Since these children must be performing below average on language to get the diagnosis SLI, this indicates that the measures are not sufficient to pick up all language problems. TD children usually have the best scores, and more often have a good performance. A few TD children

have poor scores, but only on one of the five tasks (see Table 5-12). The scores of the ADHD children fall somewhere in between. There are fewer ADHD children with poor scores than in the SLI group. In fact, only one child performs poorly on four tasks (also see Table 5-12). There are also fewer children with good scores in the ADHD group than in the TD group. The good scores of the ADHD children are found on the repetition tasks in particular (cf. Table 5-11).

5.6 Correlations between the language measures

The partial correlations between the five global language outcome measures are calculated across all groups, controlling for IQ and correcting for the number of correlations with Holm's correction (Table 5-14).

	OMS-%	PE-number	PC-CCC	ZIT-correct	NWR-correct
OMS-%	-				
PE-number	-.24	-			
PC-CCC	.24	-.19	-		
ZIT-correct	-.69**	.39**	-.24	-	
NWR-correct	-.34*	.40**	.09	.54**	-

Table 5-14: partial correlations between the five main language outcome measures (controlling for IQ); * = *p*<.01 after Holm's correction for number of correlations; ** = *p*<.001 after Holm's correction for number of correlations

The large correlation (.54) between the two repetition tasks (NWR and ZIT) is not surprising. There is also a significant correlation between each of the two repetition tasks and OMS-% on the one hand (-.69/-.34) and PE-number on the other hand (.39/.40). A relation between OMS-% and ZIT-correct might be expected since both involve grammatical knowledge. The relation between OMS-% and NWR-correct is not so transparent. The correlation between PE-

number and the two repetition measures is not clear at all. There is no significant correlation between the two pragmatic measures. Possibly these pragmatic measures are considering quite different aspects of pragmatics.

5.7 ADHD sub-groups

The main goal of the previous sections was to compare the three research groups. That is, the ADHD group was compared to the SLI group on the one hand and the TD group on the other hand. We found that the ADHD group performed worse than the TD group on some variables. However, for other variables, no difference was found between the ADHD group and the TD group. The SLI group almost always had the lowest scores (see Table 5-3 to Table 5-10). In this section we want to explore the performance of the children in the ADHD group. As has already been shown in earlier research (see Section 2.2.2), a differentiation is often made between an ADHD group with language problems and an ADHD group without language problems. From Table 5-13, we know that 31% of the ADHD children have low scores on one or more of the five global outcome measures. However, this picture is not refined enough to be able to explore the relationship with executive functioning (see third research question in Section 3.4). In Section 5.7.1 we will therefore consider the effect of dividing the ADHD group and explore the scores of the ADHD sub-groups on various language tasks. In the following section, Section 5.7.2, the relationship with reading problems will be discussed.

5.7.1 ADHD sub-groups with and without language problems

If the ADHD group is to be split into two groups, that is, with and without language problems, the first thing to consider is how to define the presence of a language problem. As discussed in Section 4.3, norm groups are available for only two of the instruments; for

the language questionnaire (CCC-II-NL) and for the sentence imitation task (ZIT). These two instruments also have a cut-off score that separates normal scores from scores indicative of language problems. Therefore, as a first step, we will look at the ADHD children's scores on the CCC-II-NL (see Section 4.3.3) and on the ZIT (see Section 4.3.2).

The CCC-II-NL gives a general communication score. This score is composed of different scales and reflects different language areas, but focuses on pragmatics. A score of equal to or above 110 represents the cut-off for the lowest 5%. That is, these children perform very poorly. A score of equal to or above 104 identifies the lowest 10% (also see Table 5-10).

The focus of the measurement of language impairment in sentence imitation tasks is on grammar (also see Section 2.1.2). The main outcome measure of the ZIT is the number of items repeated correctly. To obtain the lowest 5%, a cut-off of equal to or below 15 (out of 20) has to be used (Aan de Wiel and Drubbel, 1990; also see Table 5-8). There has been no research with SLI or children with ADHD using this specific sentence imitation task. However, research using other sentence imitation tasks shows that they can be used as a clinical marker for SLI (Conti-Ramsden, 2001; also see Section 2.1.2). Moreover, children with ADHD have been shown to have difficulties with this task as well, although less so than children with SLI (Redmond, 2005; also see Section 2.4).

Table 5-15 and Table 5-16 present the mean scores on the CCC-II-NL and the ZIT. In both these tables, the ADHD group is divided into two sub-groups, based on a 5% cut-off as discussed above.
In Table 5-15, the groups are divided on the basis of the CCC-II-NL. Eight of the 26 ADHD children have language problems according to this instrument.

The Kruskal Wallis test for the general communication composite of the CCC-II-NL confirms that performance on the composite score is affected by group membership, H(3)=40.81, $p<.001$.

CCC-II-NL	**General communication composite**	**Number of children**
ADHD+LP(CCC)	119.63 (3.07)	8
ADHD-LP(CCC)	92.67 (10.13)	18
SLI	108.79 (12.53)	14
TD	76.36 (15.76)	22

Table 5-15: general communication composite scores of the language questionnaire CCC-II-NL in means and SD (between brackets) for ADHD, SLI and TD groups. The ADHD group is divided into a group with language problems according to the CCC-II-NL (ADHD+LP(CCC)) and a group without language problems according to the CCC-II-NL (ADHD-LP(CCC)). *Note* that a high score signals low performance

Post hoc Mann-Whitney U tests with Holm's correction show significant differences between the ADHD+LP(CCC) and the ADHD-LP(CCC) groups (U=.00), between the ADHD-LP(CCC) and the SLI groups (U=38.50), between the ADHD-LP(CCC) and TD groups (U=71.50), between the ADHD+LP(CCC) and the SLI groups (U=22.00), between the ADHD+LP(CCC) and TD groups (U=.00), and, finally, between the SLI and TD groups (U=12.00). Thus, the differences can be represented as ADHD+LP(CCC)>SLI>ADHD-LP(CCC)>TD.

As discussed in Section 5.4, the general communication composite of the CCC-II-NL differentiated between the ADHD, SLI and TD groups, with the ADHD children performing better than the SLI children, but worse than the TD children. When we divide the ADHD groups into two groups (one with language problems according to the CCC-II-NL and one without language problems according to the CCC-II-NL) eight out of 26 ADHD children (31%), perform very poorly. Interestingly, these children even have worse scores than the SLI group as a whole. Furthermore, the scores of the

remaining ADHD group fall between the scores of the SLI group on the one hand and the TD group on the other hand. That is, taking out a poorly performing ADHD subgroup still leaves us with the other ADHD children who are not performing as well as the TD children on the general composite score of the CCC-II-NL.

Table 5-16 shows the division of the ADHD group on the basis of the sentence imitation task (ZIT). In this case, children with language problems as defined by the ZIT (+LP(ZIT)) have a score of 15 or lower, and fall in the lowest 5% of a norm group. This is the case for 10 children in the ADHD group.

	Number of correctly repeated items	**Number of children**
ADHD+LP(ZIT)	12.3 (3.68)	10
ADHD-LP(ZIT)	18.13 (1.41)	16
SLI	9.00 (4.47)	19
TD	17.18 (1.89)	22

Table 5-16: number of correctly repeated items on the sentence imitation task (ZIT) in means and SD (between brackets) for ADHD, SLI and TD groups. The ADHD group is divided into a group with language problems according to the ZIT (ADHD+LP(ZIT)) and a group without language problems according to the ZIT (ADHD-LP(ZIT))

The Kruskal Wallis test for the number of items repeated correctly on the ZIT confirms that performance on this outcome measure is indeed affected by group membership, $H(3)=44.85$, $p<.001$. Post hoc Mann-Whitney U tests with Holm's correction show significant differences between the ADHD-LP(ZIT) and the ADHD+LP(ZIT) groups (U=.00), between the ADHD-LP(ZIT) and the SLI groups (U=5.50), between the ADHD+LP(ZIT) and TD group (U=16.00), and, finally, between the SLI and TD groups (U=15.00). However, no significant differences are found between the ADHD+LP(ZIT) and the SLI groups (U=49.50) and the ADHD-LP(ZIT) and TD groups

(U=127). Thus, the differences can be represented as ADHD+LP(ZIT) =SLI<ADHD-LP(ZIT)=TD.

Section 5.2 showed that the numbers of items repeated correctly on the sentence imitation task differentiates the SLI group on the one hand from the ADHD and TD groups on the other hand, with the former group having the lowest scores. When dividing the ADHD groups into two groups (one with language problems according to the ZIT and one without language problems according to the ZIT) 10 out of 26 ADHD children (38%) perform very poorly. These children's scores fall in the lowest 5% of the scores of a norm group and cannot be differentiated from the scores of the SLI group. However, the scores of the remaining children with ADHD cannot be differentiated from the scores of the TD group.

Both the language questionnaire and the sentence imitation task show that a substantial subgroup of ADHD children (31% and 38% respectively) performs poorly, that is, in the clinical range, when compared to a large norm group. Since the two instruments measure different aspects of language ability, it is interesting to look at the overlap between the scores on both language instruments in these ADHD sub-groups (see Table 5-17).

	ADHD-LP(CCC)	**ADHD+LP(CCC)**
ADHD-LP(ZIT)	n=12 (46.15%)	n=4 (15.38%)
ADHD+LP(ZIT)	n=6 (23.08%)	n=4 (15.38%)

Table 5-17: relationship between scores on the language questionnaire (CCC-II-NL) and on the sentence imitation task (ZIT) in the ADHD group (number and percentage; total of 26 children)

Twelve (46%) of the children in the ADHD group have normal scores on both measures. The other 14 (54%) of the ADHD children have scores falling in the lower 5^{th} percentile when compared to a norm group on at least one of the measures. From these children,

six (23%) perform poorly on the ZIT, but not on the CCC-II-NL and four (28.5%) perform poorly on the CCC-II-NL, but not on the ZIT. Another four children (28.5%) perform poorly on both measures.

We have seen that the language questionnaire is better than the sentence imitation task in differentiating the ADHD sub-groups from the SLI group and the TD group. Furthermore, it is more specific in the kind of language abilities it actually measures. It also focuses on pragmatics, the language domain of interest in this study, since it is hypothesized that this language domain is related to executive functioning (see Section 3.3). Nevertheless, as well as eight children performing poorly on the CCC-II-NL, six other children perform poorly on the ZIT and thus also have language problems. Although these are of a different nature, namely grammatical, we do not want to neglect them. Language problems will therefore be defined as a very poor score on the CCC-II-NL, and /or the ZIT. It could be the case that the population in the two ADHD sub-groups have different characteristics in terms of age in months, gender and IQ. These data are presented in Table 5-18.

There is, however, no significant difference between age in months of the ADHD+LP and the ADHD-LP group, $F(1, 24)=.159$, $p>.05$. With regard to gender, as described in Section 4.1.4, the ADHD group was selected with 80% boys and 20% girls, in order to reflect the distribution in the general population. For the two ADHD sub-groups, the division of gender is certainly in the right direction, but not as good as it was for the ADHD group as a whole. Compared to this 80:20 split, the ADHD+LP group has a somewhat higher percentage of boys, as opposed to the ADHD-LP group with a slightly lower percentage.

Since language problems tend to occur more often in boys than in girls, this is not completely unexpected (see Section 2.1.2). There is no significant difference in non-verbal IQ between the two ADHD groups, $F(1, 24)=1.514$, $p>.05$.

	ADHD (n=26)	ADHD+LP (n=14)	ADHD-LP (n=12)
Age in months (mean and SD)	97.73 (6.32)	96.50 (6.98)	99.17 (5.37)
Gender (% and n)			
male	81% (21)	86% (12)	75% (9)
female	19% (5)	14% (2)	25% (3)
Non-verbal IQ (mean and SD)	108.65 (12.55)	111.43 (9.83)	105.42 (14.91)

Table 5-18: age in months, gender and non-verbal IQ in the ADHD group as a whole, in the ADHD group with language problems (ADHD+LP) and in the ADHD group without language problems (ADHD-LP)

5.7.1.1 Narrative in the ADHD sub-groups

We will now return to the variables of the narrative task to see how they relate to this division into sub-groups. Section 5.1, about the results of the frog story narrative, showed that there were variables that differentiated between the ADHD group as a whole on the one hand and the SLI and /or the TD group on the other hand. However, there were several variables where the contrasts did not reach the required level of significance (see Table 5-3, Table 5-4 and Table 5-5 for an overview). The large variation in scores might, at least partly, explain these results.

It could be possible that the ADHD subgroup with language problems performs worse than the ADHD group without language problems on the variables of the narrative task. However, neither of the three MANOVAs, one for each of the three categories of variables (general, grammatical and pragmatic outcome measures; see Section 4.3.1) reaches significance, so that further statistical analyses cannot be done.

The scores of the ADHD sub-groups are presented in Table 5-19, Table 5-20 and Table 5-21. The subsequent discussion will be done on the basis of the raw figures presented in these tables and their interpretation is therefore suggestive.

Frog story General measures	**ADHD+LP (n=14)**	**ADHD-LP (n=12)**
Total number of T-units	45.93 (12.70)	44.83 (14.59)
Utterances not related to story	3.21 (4.73)	1.00 (1.13)
Non-analyzable utterances	4.93 (2.30)	3.25 (2.45)
Mean length of utterance - words	6.12 (1.06)	6.73 (1.06)
Subordinate conjunctions (%)	2.66 (2.70)	6.41 (5.55)
Dysfluencies (%)	27.18 (27.44)	24.68 (11.68)
Direct speech (%)	10.98 (16.32)	7.78 (12.40)

Table 5-19: general outcome measures of the frog story in means and SD (between brackets) for ADHD+LP and ADHD-LP groups. MANOVA not significant, Wilks' Λ=.620, $F(7, 18)=1.577$, $p>.05$, $\eta_p^2=.38$

Considering the general outcome measures of the frog story (see Table 5-19), we see that the ADHD+LP group uses a more or less equal amount of T-units as the ADHD-LP group to tell the frog story. However, the ADHD+LP group uses more utterances that are not related to the story, and does have a somewhat higher number of non-analyzable utterances. The mean length of utterances in words is more or less the same. The ADHD+LP group uses a lower percentage of subordinate conjunctions, and a higher percentage of dysfluencies than the ADHD-LP group. Finally, the percentage of

direct speech is higher for the ADHD+LP group. In general, we expected that the ADHD+LP group would have more problems with the narrative task than the ADHD-LP group and the observations from Table 5-19 are in the expected direction.

The ADHD+LP group also has a considerably higher percentage of errors on all grammatical variables of the frog story (Table 5-20), as could be expected.

Frog story Grammatical measures	**ADHD+LP (n=14)**	**ADHD-LP (n=12)**
Morpho-syntactic errors (%)	26.48 (18.21)	18.11 (9.87)
Morphological errors (%)	6.14 (6.09)	3.42 (4.53)
Syntactic errors (%)	20.34 (17.01)	14.69 (8.54)
Clustered errors (%)	3.45 (3.47)	2.74 (3.29)

Table 5-20: grammatical outcome measures of the frog story in means and SD (between brackets) for ADHD+LP and ADHD-LP groups. MANOVA not significant, Wilks' Λ=.859, $F(3,22)=1.20$, $p>.05$, $\eta_p^2=.14$

We also expected that the ADHD+LP group would use fewer plot elements than the ADHD-LP group. In Table 5-21, we see that, in terms of raw scores, the total number of plot elements and the number of goals indeed is a little lower for the ADHD+LP group, compared to the ADHD-LP group. However, overall, the differences between the two groups are minimal.

In sum, the ADHD children who had a low performance on the language questionnaire and/or the sentence imitation task (i.e. the ADHD+LP group) also performed worse on the frog story in terms of raw scores. This was more so for the grammatical than for the plot analysis variables. However, there were no statistical differences.

This was probably due to the small and unequal samples, and the large variation in narrative scores.

Frog story Plot analysis measures	ADHD+LP (n=14)	ADHD-LP (n=12)
Plot elements (total)	8.93 (3.56)	9.50 (3.68)
Setting elements	1.21 (.70)	1.17 (.72)
Initiating events	3.14 (1.23)	3.17 (1.27)
Internal responses	.07 (.27)	.17 (.39)
Search attempts	3.79 (2.19)	3.83 (2.08)
Goals	.71 (.73)	1.17 (.83)

Table 5-21: plot analysis outcome measures of the frog story in means and SD (between brackets) for ADHD+LP and ADHD-LP groups. MANOVA not significant, Wilks' Λ=.833, $F(5,20)=.530$, $p>.05$, $\eta_p^2=.12$

5.7.1.2 Non-word repetition in the ADHD sub-groups

The NWR task measures receptive and expressive phonological functioning (Coady and Evans, 2008). It also taps other neuropsychological abilities, including executive functioning (Miniscalco and Gillberg, 2009). As described in Section 4.3.2, we administered a Dutch non-word repetition task, the same task that was reported upon in De Bree (2007). It contains 16 non-words of two to five syllables in length that conform to the Dutch phonotactic system. Miniscalco and Gillberg (2009) found that children with a neuropsychiatric disorder (NPD; including children with attention-deficit hyperactivity disorder) and language impairment are easily picked up by a NWR screening test. Children with SLI often also exhibit poor NWR performance. For example, Conti-Ramsden at al.

(2001) found that 75% of children with SLI have problems with this task.

In this study, we found that the SLI children indeed perform worse on the NWR task (see Section 5.3). However, the children with ADHD performed just as well as the children in the TD group (on the variable number of items repeated correctly), or did not differ from either the children in the SLI or the children in the TD groups (on the variable percentage of phonemes repeated correctly). The results of the study by Miniscalco and Gillberg (2009), would predict that the ADHD-LP group outperforms the ADHD+LP group on the NWR task. When looking at the raw figures (Table 5-22), the ADHD-LP group indeed has higher scores on both variables of the task. However, although there is a trend towards significance, the MANOVA does not reach the required level of significance. This means that further statistical analysis cannot be done.

NWR	**ADHD+LP (n=14)**	**ADHD-LP (n=12)**
Items repeated correctly (out of 16)	6.21 (2.12)	7.67 (2.02)
Phonemes repeated correctly (%)	72.15 (12.48)	82.42 (9.61)

Table 5-22: outcome measures (number of items repeated correctly, out of 16; percentage of phonemes repeated correctly) of the non-word repetition task (NWR) in means and SD (between brackets) for ADHD+LP and the ADHD-LP groups. MANOVA not significant, Wilks' Λ=.801, $F(2,23)=2.863$, $p=.08$, $\eta_p^2=.20$

As discussed above, the non-significant MANOVA result may be due to the small number of children in the unequal ADHD sub-groups. Another explanation for the non-significant result might be that the non-word repetition task measures another language domain, phonology, instead of focusing mainly on pragmatics (CCC-II-NL) and/or grammar (ZIT).

Section 5.7.2 will also discuss findings of the non-word repetition task, albeit from a different perspective. That is, these results will not be related to language problems, but to reading problems in ADHD.

5.7.2 ADHD sub-groups with and without reading problems

Section 4.1.4 showed that reading problems were also assessed in this study. On the basis of these data, we were able to divide the ADHD group in two subgroups (i.e. with reading problems (+RP) and without reading problems (-RP)). There is no significant difference in age between the ADHD+RP and the ADHD-RP group, $F(1,24)=.457$, $p>.05$. With regard to gender, the division is certainly in the right direction. However, the ADHD+RP group has a somewhat higher percentage of boys, as opposed to the ADHD-RP group with a slightly lower percentage of boys than the expected 80:20 split. Furthermore, there is no significant difference in non-verbal IQ between the two ADHD sub-groups, $F(1, 24)=2.198$, $p>.05$ (see Table 5-23).

	ADHD (n=26)	**ADHD+RP (n=8)**	**ADHD-RP (n=18)**
Age in months (mean and SD)	97.73 (6.32)	99.00 (6.65)	97.17 (6.27)
Gender (% and n)			
male	81% (21)	87.5% (7)	77.8% (14)
female	19% (5)	12.5% (1)	22.2% (4)
Non-verbal IQ (mean and SD)	108.65 (12.55)	114.00 (15.78)	106.27 (10.46)

Table 5-23: age in months, gender and non-verbal IQ in the ADHD group as a whole, in the ADHD group with reading problems (ADHD+RP) and in the ADHD group without reading problems (ADHD-RP). For reasons of comparability, group division is based on the mean score of two reading tasks, in accordance with Rispens and Parigger (2010; cf. Table 4-3, with six instead of eight ADHD+RP children)

Indeed, when comparing the figures in Table 5-23 and Table 5-18, presenting the same characteristics for the ADHD group with language problems and the ADHD group without language problems, we see that they are very much alike. There is in fact considerable overlap between the sub-groups. This was already visualized in Figure 2-1, where three circles represent three groups of children: one with symptoms of inattention/hyperactivity-impulsivity, one with language problems and one with reading problems. The three circles overlap in four places.

Out of the 30 children with ADHD symptoms, nine had additional language problems, and three had additional reading problems. Moreover, 10 children with ADHD symptoms had both language and reading problems. On the other hand, out of the 33 children with language problems, six also had reading problems. There were only three children with language problems-only. Similarly, there were only eight children with ADHD symptoms-only. So, there is a huge amount of symptom overlap.

We correlated measures of ADHD, language and reading and indeed found significant correlations (see Table 5-24); a large correlation between ADHD and language and a medium to large correlation between language and reading. We will come back to this issue in Section 8.3.

We will now explore whether or not ADHD children with reading problems experience more problems with non-word repetition than ADHD children without reading problems.

Research in the field of non-word repetition is normally carried out in groups of children with SLI. However, it may very well be that only those SLI children who also present with reading problems (RP) are challenged by the non-word repetition task.

	ADHD	Language	Reading
ADHD	-		
Language	.48**	-	
Reading	.15	-.39*	-

Table 5-24: correlations between ADHD (defined as the combined score of the inattention and hyperactivity-impulsivity scales of the VVGK, n=62), language (defined as the general communication composite of the CCC-II-NL, n=67) and reading (defined as the combined score of the EMT and Klepel, n=67). For ADHD and language, higher scores mean poorer performance; for reading, higher scores mean better performance. * = *p*<.01 after Holm's correction for number of correlations; ** = *p*<.001 after Holm's correction for number of correlations

This was suggested in, for example, Rispens and Baker (in press) and Rispens and Parigger (2010). In the latter study, 7- and 8-year-old children with SLI (n=29) did a NWR task with non-words of 2, 3, 4 or 5 syllables in length. TD children of the same age (n=15) did the task too. SLI children without reading problems (n=11) did not differ on any of the four conditions from the TD children. SLI children with reading problems (n=18) scored significantly more poorly on the 3, 4 and 5 syllable conditions compared to the TD group. Non-word repetition performance was especially poor on the 3 and 4 syllable conditions for the SLI+RP children, compared to the SLI-RP children. Furthermore, the data seemed to underline the dependency relation between non-word repetition and literacy development[39].

Table 5-25 shows that the raw scores are in the expected direction, with the ADHD+RP group having the lowest scores. However, the MANOVA turns out not to be significant, and further statistical analyses cannot be done.

From Rispens and Parigger (2010), we know that the mean number of items repeated correctly is 5.82 for the SLI-RP group, and 3.94 for the SLI+RP group. We also know the mean percentage of phonemes repeated correctly: 79.50 for the SLI-RP group and 70.75

[39] Also see Parigger and Rispens (2010).

for the SLI+RP group. So, in terms of raw scores, the SLI+RP group is doing worse than the ADHD+RP group.

NWR	ADHD+RP (n=8)	ADHD-RP (n=18)	TD (n=15)
Items repeated correctly (out of 16)	6.13 (2.36)	7.22 (2.05)	6.60 (2.77)
Phonemes repeated correctly (%)	75.88 (11.39)	77.34 (12.83)	82,53 (8.26)

Table 5-25: outcome measures (number of items repeated correctly, out of 16; percentage of phonemes repeated correctly) of the non-word repetition task (NWR) in means and SD (between brackets) for ADHD+RP and the ADHD-RP groups, as well as for the TD group. For reasons of comparability, this TD group is taken from Rispens and Parigger (2010). MANOVA not significant, Wilks' Λ=.820, $F(4,72)=.1.875$, $p>.05$, $\eta_p^2=.13$

This might be related to the literacy level of the children. Although we do not have data on the general literacy level of the children in this study, it is probable that the ADHD children have a higher literacy level than the SLI children.

5.8 Summary of language measures

This chapter focused on the first of the three research questions of this study, which was previously discussed in Sections 2.4 and 3.4:

Do children with ADHD differ in language production in comparison with typically developing children and do they differ from SLI children?

Children with ADHD were found to differ in language production in comparison with typically developing children, most notably so when looking at pragmatics. Moreover, the ADHD group could be differentiated from the SLI group since they did better on phonological and grammatical measures. However, in the case of

pragmatics, there was less of a difference between the two groups, both performing more poorly than the typically developing group.
These findings were reflected also in the within-group and individual comparisons. Moreover, a considerable overlap was found for symptoms of inattention/hyperactivity-impulsivity, language problems and reading problems.

6

Results of executive functioning measures

This chapter aims to provide an answer to the second of the three research questions, about executive functioning of children with ADHD in comparison with SLI and TD children (Sections 3.2.2 and 3.4).

Table 4-7 (repeated as Table 6-1) gives an overview of the (outcome) measures in the assessment of executive functioning (see Section 4.4).

The performance of the ADHD, SLI and TD children on each of the executive functions will be described in Section 6.1. The executive functions will then be discussed both within groups and at an individual level (Section 6.2). To complete the data, (partial) correlations between the executive functions will be reported (Section 6.3). Finally, in Section 6.4, the general conclusions will be reported.

6.1 Results of the executive functions

Generally, we expect ADHD children to perform the worst on the executive functioning tasks, and typically developing children the best. This is in particular the case for inhibition; results for the other executive functions are not always consistent. Although less research

is available, the same is suggested for SLI children's executive functioning profile.

Function	Test	Outcome measures
Inhibition	CANTAB-SST (stop signal task)	• SSRT
Working memory	CANTAB-SWM (spatial working memory)	• between-search errors • within-search errors • strategy score
Planning	CANTAB-SOC (stockings of Cambridge)	• problems solved in minimum moves • mean moves for n-move problems
Cognitive flexibility	CANTAB-IED (intra-/extradimensional shift)	• stages completed • total trials (adjusted) • errors blocks 2/5/7/9 • errors blocks 6/8
Non-verbal fluency	Paper-and-pencil-FPT (five point test)	• unique designs (%) • perseverations (%)

Table 6-1 (copy of Table 4-7): overview of all tests and outcome measures used in the neuropsychological assessment

The results of the executive functioning measures will be discussed in separate sections: Section 6.1.1 (inhibition), Section 6.1.2 (working memory), Section 6.1.3 (planning), Section 6.1.4 (cognitive flexibility), and Section 6.1.5 (non-verbal fluency). Section 6.1.6 will provide an interim summary on the results of these five executive functions.

6.1.1 *Inhibition*

Inhibition is measured using the stop signal task (SST; also see Section 4.4). Three out of the 26 children in the ADHD group did not finish the SST. The test was either abandoned by the child (once) or it was ended due to a system error (twice). The selected outcome measure is the stop signal reaction time (SSRT). The results (in means and SD) are shown in Table 6-2.

SST	**ADHD (n=23)**	**SLI (n=18)**	**TD (n=21)**	**Contrasts**
SSRT	313.00 (71.34)	264.76 (72.00)	250.02 (58.92)	ADHD<SLI=TD

Table 6-2: outcome measure (stop signal reaction time [SSRT] of SST in means and SD (between brackets) for ADHD, SLI and TD groups. The contrast are reported in the last column

The SSRT estimates the length of time between the go stimulus and the stop stimulus at which the subject is able to successfully inhibit their response on 50% of trials. Two significant outliers were removed from the SSRT data, one from the SLI group, and one from the TD group. Group differences emerge from the ANOVA for the SSRT, $F(2, 59)=5.229$, $p<.01$, $\eta_p^2=.15$. The significant contrasts are reported in Table 6-2. The ANCOVA with non-verbal IQ as a covariate reveals the same pattern of results. The SLI and TD group could not be differentiated from each other in terms of SSRT, in contrast to the results of other studies (see Section 3.2.2). The ADHD group did have slower SSRT's compared to both the SLI and the TD group, indicating greater difficulty in response inhibition. Geurts (2003) also found that ADHD children performed worse than TD children, all of them Dutch, on a measure for inhibition.

6.1.2 Working memory

Working memory is measured using the Spatial Working Memory task (SWM; also see Section 4.4). The SWM consists of 3 to (4 to 6 to) 8 box problems. Three SWM outcome measures are selected: two error-scores (between-search errors (BSE) and within-search errors (WSE)) and one strategy-score (SS). Low scores on either BSE or WSE indicate a small number of errors. A low SS also signals good performance and is given to search sequences that consistently start from the same box. The results of the outcome measures (in means and SD) are shown in Table 6-3. The MANOVA for the nine main outcome measures is not significant. Co-varying for IQ does not alter the results. We will, however, take a closer look at the results in terms of raw scores.

Returning to an empty box where a blue token has already been found is referred to as a between-search error. Table 6-3 shows that the ADHD group and the SLI group make more between-search errors than the TD group. The ADHD and SLI children score very similarly. Using a different visual working memory measure, Geurts (2003) did not find any significant difference between Dutch ADHD and TD children either.

The repeated measures ANOVA with Greenhouse Geisser correction for the 4-box, 6-box and 8-box problems shows a significant within subject effect, $F(1.44, 91.86)=.448.02$, $p<.001$, $\eta_p^2=.88$. More between-search errors are made as the difficulty of the problem increases. The repeated measures ANOVA does not show a significant interaction effect.

A within-search error refers to responses to a box previously opened and shown to be empty. As can be seen in Table 6-3, this does not happen very often. Unlike the previous outcome measure, and in terms of raw scores, there are no obvious differences between the ADHD group, the SLI group and the TD group. Maybe this is because the time frame in which within-search errors can be made is

shorter than the time frame for between-search errors. Consequently, not making between-search errors might be more demanding, and might thus differentiate better between the clinical groups on the one hand and the typically developing group on the other hand.

SWM	**ADHD (n=26)**	**SLI (n=19)**	**TD (n=22)**
BSE–total	46.73 (13.51)	47.26 (10.56)	42.55 (13.74)
BSE–4 boxes	1.50 (1.66)	1.26 (1.94)	1.18 (1.65)
BSE–6 boxes	13.54 (6.41)	13.79 (5.77)	10.27 (4.60)
BSE–8 boxes	31.69 (9.74)	32.21 (7.34)	31.09 (10.56)
WSE–total	2.35 (3.36)	1.58 (2.50)	3.00 (2.41)
WSE–4 boxes	.12 (.59)	.00 (.00)	.14 (.47)
WSE–6 boxes	.19 (.49)	.26 (.65)	.36 (.90)
WSE–8 boxes	2.04 (3.18)	1.32 (2.08)	2.50 (2.39)
SS–total	37.50 (3.34)	37.21 (2.95)	36.05 (3.59)

Table 6-3: outcome measures (between-search errors [BSE], within-search errors [WSE] and strategy score [SS]) of SWM in means and SD (between brackets) for ADHD, SLI and TD groups. MANOVA not significant, Wilks' Λ=.847, F(14, 116)=.716, p>.05, η_p^2=.08

The ANOVA with repeated measures for the 4-box, 6-box and 8-box problems, and with Greenhouse Geisser correction, shows a significant within subject effect, $F(1.16, 74.00)=27.65$, $p<.001$, $\eta_p^2=.30$. With increasing level of difficulty, more within-search errors are

made. The repeated measures ANOVA again does not show a significant interaction effect.

A strategy score is estimated from the number of searches that start from the same location. A low strategy score signals better performance and is given to search sequences that consistently start from the same box. The results in Table 6-3 show very similar raw strategy scores for the ADHD, SLI and TD groups.

When interpreting the working memory data from this study, it should be borne in mind that we used a non-verbal task. We did this explicitly to prevent confounds with the language data (also see Section 4.4). However, it should be noted that most of the research on working memory in SLI reports on verbal working memory. Although there were no significant differences between the SLI and the TD groups on the non-verbal measure reported in this section, there were differences on the verbal working memory measure, which were reported in Section 5.3. This is in line with the findings by Henry, Messer and Nash (2012)

6.1.3 Planning

Planning is measured using the Stockings of Cambridge task (SOC; also see Section 4.4). The SOC consists of 2- to 5-move problems. Two SOC outcome measures are selected: problems solved in minimum moves (PSMN) and mean moves for n-move problems (MMNP).

One out of the 26 children in the ADHD group failed the SOC; it is not clear why. The MANOVA for the nine outcome measures is not significant. Co-varying for IQ does not alter the results. We can only interpret the results of Table 6-4 in terms of raw scores.

The first outcome measure, problems solved in minimum moves, is an important one. This is a measure of overall planning accuracy. Table 6-4 shows that the TD group completes more test problems in

the minimum possible number of moves than both the ADHD group and the SLI group, although only so in terms of raw scores. In another Dutch study, Geurts (2003) did not find a significant difference between Dutch ADHD and TD children on a planning measure either.

SOC	ADHD (n=25)	SLI (n=19)	TD (n=22)
PSMM–total	5.88 (1.74)	5.95 (1.68)	6.77 (1.82)
PSMM–2moves	1.80 (.41)	1.84 (.37)	1.91 (.29)
PSMM–3moves	1.24 (.78)	1.11 (.74)	1.55 (.60)
PSMM–4moves	1.80 (.82)	1.95 (.85)	1.95 (1.09)
PSMM-5moves	1.04 (.89)	1.05 (1.13)	1.36 (.90)
MMNP–2moves	2.20 (.41)	2.18 (.45)	2.07 (.23)
MMNP–3moves	3.70 (.85)	3.89 (.89)	3.30 (.40)
MMNP–4moves	6.04 (.93)	5.79 (.99)	5.78 (1.12)
MMNP–5moves	8.06 (1.51)	8.29 (1.53)	8.31 (1.77)

Table 6-4: outcome measures (problems solved in minimal moves [PSMM] and mean moves for n-move problems [MMNP]) of SOC in means and SD (between brackets) for ADHD, SLI and TD groups. MANOVA not significant, Wilks' Λ=.777, $F(16, 112)=.942$, $p>.05$, $\eta_p^2=.12$

The repeated measures ANOVA with Greenhouse Geisser correction for 2-move, 3-move, 4-move and 5-move problems shows a significant within subject effect, $F(2.43, 155.27)=17.39$, $p<.001$, $\eta_p^2=.21$.

This means that fewer problems are solved in the minimum possible number of moves when the difficulty level increases. The repeated measures ANOVA does not show a significant interaction effect.

The second outcome measure, mean moves for n-move problems, describes the mean number of moves required by the subject to solve problems with solutions possible in 2, 3, 4 or 5 moves respectively. The results are presented in Table 6-4. The raw scores of the ADHD, the SLI, and the TD group hardly differ. However, generally speaking, the clinical groups need more moves than the typically developing group.

6.1.4 Cognitive flexibility

Cognitive flexibility is measured using the intra-/extradimensional shift task (IED; also see Section 4.4). There are nine IED stages to be completed. Four IED outcome measures are selected: two scores for the number of stages/trials completed (SC/TT-A) and two error-scores (TE-2579/TE-68). The MANOVA for the four outcome measures again is not significant. Co-varying for IQ does not alter the results. Raw scores from Table 6-5 will be used to indicate trends.

The stages completed score consists of the total number of stages completed successfully. Table 6-5 shows that the ADHD group, the SLI group and the TD group do not differ substantially, even in terms of raw scores. The total trials score consists of the total number of trials completed on all attempted stages, with an adjustment for any stages not reached. Again, the raw scores on this outcome measure hardly differ. Furthermore, one of the error-scores reflects the total number of errors made in blocks 2, 5, 7 and 9. This score provides a good measure of reversal learning. The ADHD group makes the fewest reversal errors and the SLI group makes the most. The scores of the TD group fall in between the scores of the two clinical groups. It is unclear why this is the case.

IED	ADHD (n=26)	SLI (n=19)	TD (n=22)
SC	7.92 (1.55)	8.11 (.99)	8.09 (.97)
TT-A	125.38 (61.01)	122.74 (37.32)	117.27 (38.92)
TE-2579	6.31 (4.86)	9.63 (8.15)	7.86 (6.58)
TE-68	16.54 (11.03)	16.58 (10.81)	14.68 (12.09)

Table 6-5: outcome measures (stages completed [SC], total trials – adjusted [TT-A], total errors 2/5/7/9 [TE-2579], total errors 6/8 [TE-68] of IED in means and SD (between brackets) for ADHD, SLI and TD groups. MANOVA not significant, Wilks' Λ=.930, $F(8, 122)=.568$, $p>.05$, $\eta_p^2=.04$

The other error-score reflects the total number of errors made in blocks 6 and 8. This is a measure of attentional flexibility - an important outcome measure. Table 6-5 shows that, as expected, the ADHD group and the SLI group make more of these errors than the TD group, in terms of raw scores. However, there is no obvious difference between the ADHD group and the SLI group. Another Dutch study, comparing ADHD children to TD children (Geurts, 2003), did not find significant differences in terms of cognitive flexibility either.

6.1.5 Non-verbal fluency

A traditional paper-and-pencil test was conducted in order to obtain a measure of non-verbal fluency, since the CANTAB testing battery does not contain such a test. The test used was the five-point test (FPT) of Regard (1982), with a three-minute-limit (Lee et al., 1997), adapted for Dutch by Parigger (2006; see Section 4.4). Two scores are of interest: the repeated score for all repeated designs (perseverations (PP)), and the unique score for all unique designs (PUD). In order to interpret these scores more easily, they are

reported in percentages, that is: percentage of perseverations (repeated designs / total designs * 100) and percentage of unique designs (unique designs / total designs * 100).

Unfortunately, for approximately half of the children, only one-minute scores are available. Thus, the results will be discussed for both one-minute scores (all children) and three-minute scores (subset of all children: zero out of 19 SLI children; 12 out of 22 TD children and 26 out of 26 ADHD children; see also Table 6-6).

FPT	**ADHD (n=26)**	**SLI (n=19)**	**TD (n=22)**
PP1	6.54 (11.12)	1.71 (5.27)	2.82 (7.31)
PUD1	93.46 (11.12)	98.29 (5.27)	97.18 (7.31)
PP3	20.90 (25.80)	not available[a]	11.59[a] (13.58)
PUD3	79.10 (25.80)	not available[a]	88.41[a] (13.58)

[a] SLI: n=0; TD: n=12

Table 6-6: outcome measures (percentage of perseverations after one minute [PP1], percentage of unique designs after one minute [PUD1], percentage of perseverations after three minutes [PP3], and percentage of unique designs after three minutes [PUD3] of FPT in means and SD (between brackets) for ADHD, SLI and TD groups. MANOVA (one-minute version) not significant, Wilks' Λ=.941, $F(2, 64)=.2.014$, $p>.05$, $\eta_p^2=.06$. MANOVA (three-minute version) not significant, Wilks' Λ =.963, $F(1, 36)=1.372$, $p>.05$, $\eta_p^2=.04$

The MANOVAs are not significant and the MANCOVAs with non-verbal IQ as a covariate reveal the same pattern of results. The results from Table 6-6 will therefore be discussed in terms of raw scores.

The ADHD group has a higher percentage of perseverations after one minute than both the SLI group and the TD group. The percentage of unique designs after one minute mirrors the previous score. The same picture emerges for both three-minute scores in

Table 6-6. So, on this non-verbal fluency measure, ADHD children perform worse than SLI and TD children, at least in terms of raw scores. Geurts (2003) did report significant differences between Dutch ADHD and TD children, but this was on a measure of verbal fluency.

6.1.6 Results of the executive functions – interim summary

On the basis of the literature, we expected most problems to occur on measures of inhibition in the clinical groups. We were less sure about expectations for the measures of working memory, planning, cognitive flexibility and non-verbal fluency.

Significant differences were found for the measure of inhibition (Section 6.1.1). As expected, ADHD children had greater difficulties than both SLI and TD children. The SLI children did not differ significantly from TD children. No significant differences were found on any of the other four measures.

The small number of children in each group and the large variation in scores could account for the non-significant results. However, considering the raw scores, ADHD children in general had the worst scores and TD children the best, and SLI children had scores in between. In the following section these tentative findings will be explored in more detail by comparing the results of the five main executive functioning outcome measures.

6.2 Comparisons of the executive functions

In order to compare performance on the five tasks, the five most important outcomes, one for each executive function, were transformed into z-scores, with a mean of 0 and a SD of 1. These were the SSRT (stop signal reaction time of the SST - inhibition, see Table 6-2), the SWM-be (total between search errors of the SWM - working memory, see Table 6-3), the SOC-psm (total problems solved in minimal moves of the SOC – planning, see Table 6-4), the

IED-68 (total errors 6/8 of the IED - cognitive flexibility, see Table 6-5) and FPT-pp1 (percentage of perseverations after one minute of the FPT - non-verbal fluency, see Table 6-6). When necessary for correct interpretation, we also reversed these z-scores. Scores less than 1 SD from the mean were considered to reflect normal performance. Scores equal to or more than 1 SD from the mean were considered to reflect either bad (≤-1) or good (≥+1) performance. Group performances were calculated in percentages, to correct for the different sample sizes. We used this information to evaluate within-group performance (Section 6.2.1) and individual performance (Section 6.2.2).

6.2.1 Within-group comparisons

Table 6-7 displays the results of the five main outcomes (see Section 6.2) for the ADHD, SLI and TD children. Each group is divided into sub-groups with either normal performance, or relatively bad or good performance, as was done for the language measures in Table 5-11.

Generally speaking, it is clear that there are higher percentages of ADHD children in the worst of the three categories. There are more TD children in the best of the three categories. SLI children's scores fall somewhere in between.

Differences between the three groups are most notable on the SSRT (inhibition), SOC-psm (planning), and FPT-pp1 (non-verbal fluency). On the SWM-be (working memory) and the IED-68, the percentages are closer together, indicative of smaller differences. This is especially the case when looking at the children with scores equal to or below 1 SD from the mean. These findings generally reflect the findings, in terms of raw scores, in Sections 6.1.1 to 6.1.5.

However, it is also clear that there are some children in both the ADHD and the SLI groups that perform equal to or above 1 SD from the mean on measures of executive functioning.

Outcome measure	ADH ≤-1	ADH ≈0	ADH ≥+1	SLI ≤-1	SLI ≈0	SLI ≥+1	TD ≤-1	TD ≈0	TD ≥+1
SSRT	25%	75%	0%	11%	68%	21%	9%	77%	14%
SWM-be	19%	66%	15%	16%	79%	5%	18%	55%	27%
SOC-psm,	27%	61%	12%	16%	68%	16%	9%	55%	36%
IED-68	19%	58%	23%	21%	63%	16%	18%	50%	32%
FPT-pp1	19%	81%	0%	5%	95%	0%	9%	91%	0%
Total	22%	68%	10%	14%	75%	11%	12%	66%	22%

Table 6-7: distribution of ADHD (n=26; SSRT: three missing cases), SLI (n=19) and TD (n=22) children across scoring categories on each of the executive function outcome measures. All outcome measures were transformed into z-scores (and reversed when necessary) to make comparisons possible. Scores less than 1 SD from the mean are considered to reflect normal performance (≈0). Scores equal to or more than 1 SD from the mean are considered to reflect relatively bad (≤-1) or relatively good (≥+1) performance. Group performances are given in percentages, to correct for the different sample sizes

That is, these children perform better than normal. By considering individual performances, more insight will be gained into the variation amongst the groups.

6.2.2 Individual comparisons

Table 6-8 displays the results of the individual performances of the ADHD, SLI and TD children on the five selected main outcomes (see Section 6.2). The table should be read as follows: the score '0-1' for the individual ADH1, in the first column, means that this particular child had zero out of five scores equal to or more than 1 SD below the mean. That is, he performed poorly on none of the selected outcome measures. The same child had one out of five scores equal to or above 1 SD from the mean, thus performing relatively well on one of the selected outcome measures. By implication, the other four scores were in the normal range.

Table 6-8 is derived from the figures in Table 6-7 (which will not be further discussed).

Group +nr.	Nr. ≤-1	Nr. ≥+1	Group +nr.	Nr. ≤-1	Nr. ≥+1	Group +nr.	Nr. ≤-1	Nr. ≥+1
ADH1	0	1	SLI1	1	0	TD1	0	1
ADH2	0	0	SLI2	0	1	TD2	2	0
ADH3	1	1	SLI3	0	1	TD3	1	1
ADH4	0	0	SLI4	2	1	TD4	0	2
ADH5	0	0	SLI5	0	2	TD5	0	0
ADH6	0	0	SLI6	0	0	TD6	1	1
ADH7	2	0	SLI7	0	1	TD7	0	2
ADH8	0	1	SLI8	0	1	TD8	0	2
ADH9	1	1	SLI9	2	0	TD9	0	1
ADH10	2	0	SLI10	1	0	TD10	0	1
ADH11	0	1	SLI11	3	0	TD11	0	1
ADH12	1	1	SLI12	0	0	TD12	0	3
ADH13	4	0	SLI13	1	0	TD13	0	1
ADH14	3	1	SLI14	0	3	TD14	3	0
ADH15	0	0	SLI15	1	0	TD15	0	1
ADH16	0	1	SLI16	1	0	TD16	0	3
ADH17	0	0	SLI17	0	0	TD17	2	0
ADH18	1	0	SLI18	0	0	TD18	1	0
ADH19	0	1	SLI19	1	1	TD19	0	1
ADH20	1	1				TD20	0	2
ADH21	0	1				TD21	2	0
ADH22	3	0				TD22	2	1
ADH23	3	0						
ADH24	0	1						
ADH25	2	1						
ADH26	4	0						

Table 6-8: overview of scores of individual ADHD (n=26), SLI (n=19) and TD (n=22) children. In each column, the scores reflect poor (left-hand side) versus good (right-hand side) performance, based on counts of z-scores being equal to or more than 1 SD from the mean. This is counted over the five most important outcome measures (cf. Table 6-7)

It shows the percentage of children in the ADHD, SLI and TD groups that score ≤-1 SD from the mean, that is, have a poor performance on either none of the five global outcomes, on one or two outcomes, or on three or more outcomes. The same options are also displayed for the scores that are ≥+1 SD from the mean. Thus, for example, the upper left cell reporting figures of the ADHD group shows that 50% of the ADHD children do not perform below average on any task. On the other hand, 31% perform below average on one or two tasks, and the remaining 19% are below average on more than three tasks.

This table confirms again the poorer performance of ADHD children. This pertains to only 50% of them, including the 19% performing quite poorly. This is far more than the 5% in the SLI group. It is however interesting that 50% of the ADHD children also are performing quite well on some or more tasks; the same applied to 42% of the SLI children.

Scores	**ADH 0**	**ADH 1-2**	**ADH 3-5**	**SLI 0**	**SLI 1-2**	**SLI 3-5**	**TD 0**	**TD 1-2**	**TD 3-5**
≤-1SD from mean	50%	31%	19%	53%	42%	5%	64%	32%	4%
≥+1SD from mean	50%	50%	0%	58%	37%	5%	27%	64%	9%

Table 6-9: percentage of ADHD (n=26), SLI (n=19) and TD (n=22) children that score, respectively, 0/5, 1-2/5 or 3-5/5 times ≤-1 SD from the mean, and, likewise, ≥+1 SD from the mean

We must therefore conclude that executive dysfunctioning cannot account for all of the symptoms in ADHD. This has also been suggested by other authors, most notably so by Sonuga-Barke (e.g. 2002; 2003; 2005). Instead of focusing on common, simple core deficits, he proposes multiple developmental pathways to ADHD. More specifically, he distinguishes between the executive dysfunction

accounts on the one hand and the motivationally based accounts that focus on altered reward systems resulting in attempts to escape or avoid delay on the other hand. While traditionally regarded as competing, Sonuga-Barke presents these two types of accounts as complementary accounts resulting in two psycho-patho-physiological subtypes of ADHD. He also recognizes that, depending on future research, other pathways might also be possible[40].

6.3 Correlations between the executive functions

To complete the executive function results presented so far, Table 6-10 displays the partial correlations between the five executive functions, controlling for IQ and correcting for the number of correlations with Holm's correction.

	SSRT	SWM-be	SOC-psm	IED-68	FPT-pp1
SSRT	-				
SWM-be	.38*/**	-			
SOC-psm	-.18	-.29*	-		
IED-68	.01	.09	-.30*	-	
FPT-pp1	-.27	-.22	.11	-.26*	-

Table 6-10: partial correlations between the five main executive function outcome measures (controlling for IQ). *<.05 before Holm's correction for number of correlations; **<.05 after Holm's correction for number of correlations

Only one result remains significant after Holm's correction, namely the moderate correlation between the SSRT (inhibition) and the SWM (working memory). A review by for example Miyake et al. (2000) concluded that the inter-correlations between different executive functions indeed usually are rather low (*r*= <.40 or lower),

[40] The so-called neuroconstructivist approach, described by Karmiloff-Smith (1998) also implies 'multiple developmental pathways', in this case to SLI. She is however less specific when describing these pathways.

and often not statistically significant. This has been a highly consistent finding over various studies, and is confirmed here.

6.4 Summary of executive functioning results

This chapter focused on the second of the three research questions of this study, which was previously discussed in Sections 3.2.2 and 3.4:

Do children with ADHD differ in executive functioning in comparison with typically developing children and do they differ from SLI children?

Children with ADHD were found to differ significantly from both SLI and TD children only on the measure for inhibition (ADHD<SLI=TD). No significant differences between these three groups were reported for the other four measures (working memory, planning, cognitive flexibility and non-verbal fluency). The raw scores were as expected, with the ADHD children having the lowest performance (see Section 6.1.6). Within-group and individual comparisons also generally showed that ADHD children had the worst scores, TD children had the best scores, and that SLI children's scores fell somewhere in between. However, these comparisons also showed that about half of the ADHD group performed relatively well on executive functioning tasks. That is, executive dysfunctioning cannot explain all of the ADHD symptoms (cf. Sonuga-Barke, 2005). We will discuss this finding further in Section 8.3.

7

Comparing language and executive functioning results

This relatively more explorative chapter seeks to find an answer to the third of the three research questions, about the association between executive functioning and language in ADHD, SLI and TD children (Sections 3.3 and 3.4).

The model of Tannock and Schachar (1996) predicts that pragmatic language measures are associated with measures of executive functioning. The literature review in Section 3.2.1 gave rise to the more specific prediction that inhibition will show the highest correlation with pragmatic language measures. Correlations between measures of grammar and executive functions were not specifically predicted on the basis of the model (also see Sections 3.3 and 3.4).

Section 7.1 presents the partial correlations between the various measures. Section 7.2 will elaborate on executive functioning in ADHD children with language problems on the one hand and in ADHD children with reading problems on the other hand (also see Section 5.7), and Section 7.3 will compare the measures in the ADHD, SLI and TD groups at an within-group and at an individual level. The findings will be summarized in Section 7.4.

7.1 Correlations between language and executive functioning measures

We used the main outcome measures for language and executive functioning to examine the correlations. For language (see Sections 5.5 and 5.6), these were the total number of plot elements in the frog-story (PE-number), the pragmatic composite in the children's communication checklist (PC-CCC), the percentage of morpho-syntactic errors in the frog-story (OMS-%), the items repeated correctly in the sentence imitation task (ZIT-correct), and the items repeated correctly in the non-word repetition task (NWR-correct). For executive functioning (see Section 6.2 and 6.3), the main measures were the stop signal reaction time (SST-SSRT – inhibition), the total between search errors (SWM-be – working memory), the total problems solved in minimal moves (SOC-psm – planning), the total errors 6/8 (IED-68 – cognitive flexibility) and percentage of persever-ations after one minute (FPT-pp1 – non-verbal fluency).

7.1.1 Pragmatics in relation to executive functioning

	SSRT	SWM-be	SOC-psm	IED-68	FPT-pp1
PE-number	-.27	.12	.01	-.04	.36
CCC-PC	.12	-.04	-.22	.01	-.13

Table 7-1: partial correlations between the two main pragmatic outcome measures and the five main executive function outcome measures (controlling for IQ). All results are non-significant after Holm's correction for number of correlations

As Table 7-1 shows, a significant correlation between the pragmatic outcome measures on the one hand and the executive functioning measures on the other hand could not be established. The reported correlations are generally low, although the correlations with the measure for inhibition (SSRT), and the measure for non-verbal fluency (FPT-pp1) are a little higher. The lack of significant

correlations can be viewed as evidence against Tannock and Schachar's model (1996).

7.1.2 *Grammar in relation to executive functioning*

There is also no significant correlation between the grammatical outcome measures and the executive functioning outcome measures (see Table 7-2). The reported correlations are generally low, but somewhat higher for the inhibition measures (SSRT) and the cognitive flexibility measure (IED-68). This finding is in line with the general predictions.

	SSRT	**SWM-be**	**SOC-psm**	**IED-68**	**FPT-pp1**
OMS-%	.28	.09	-.20	.26	.04
ZIT-correct	-.31	-.15	.06	-.48	-.10
NWR-correct	-.15	-.15	.05	-.17	.03

Table 7-2: partial correlations between the three main grammatical outcome measures and the five main executive function outcome measures (controlling for IQ). All results are non-significant after Holm's correction for number of correlations

The outcome measure for the non-word repetition task was included in this table to complete the data presented, even though grammatical abilities are assessed only indirectly with this measure (see Section 2.1.2). Also, there could be an overlap between both repetition tasks (ZIT-correct and NWR-correct) and the working memory measure (SWM-be), because all tasks clearly involve memory. As it turned out, however, the correlation between the two repetition tasks on the one hand, and the working memory measure on the other hand is only -.15, and not significant. That is, there is no association between the verbal and the non-verbal working memory measures. This is counterintuitive, but in line with findings by for example Henry, Messer and Nash (2012).

As was noted before, in Chapter 5 and 6, the small number of children and the large variation in scores could also explain the non-significant results. Therefore, we will take a closer look at the performance of individual ADHD children in Section 7.2.

7.2 Executive functioning in ADHD sub-groups

In order to further investigate the possible relationship between executive functioning and language, the sub-groups of the ADHD group will be used: with or without language problems (see Section 5.7.1) and with or without reading problems (see Section 5.7.2). As was seen in these sections, the sub-groups are small, often leading to non-significant results. The raw scores will therefore also be interpreted.

Executive functioning domain (outcome measure)	**ADHD+LP (n=13)**	**ADHD-LP (n=10)**
Inhibition (SSRT)	324.55 (78.92)	298.00 (60.78)
Working memory (SWM-be)	44.54 (12.95)	43.50 (9.80)
Planning (SOC-psm)	5.38 (1.98)	6.30 (1.89)
Cognitive flexibility (IED-68)	17.54 (12.21)	15.80 (9.54)
Non-verbal fluency (FPT-pp1)	9.72 (13.84)	3.25 (7.06)

Table 7-3: main outcome measures in the domain of executive functioning in means and SD (between brackets) for ADHD+LP and the ADHD-LP groups. MANOVA not significant, Wilks' Λ=.800, $F(5,17)=.852$, $p>.05$, $\eta_p^2=.20$. *Note* that one child from the ADHD+LP groups is missing, and two from the ADHD-LP group, due to missing SSRT data (see Sections 4.5.1 and 6.1.1)

7.2.1 ADHD children with language problems

The main executive functioning scores of the children in the ADHD+LP group and in the ADHD-LP group do not differ significantly (see Table 7-3).

As was discussed in Section 6.1, high scores on the measures for inhibition, working memory, cognitive flexibility and non-verbal fluency mean low performance. However, this is not the case for the planning measure, where a high score signals good performance. When looking at the raw figures, the ADHD-LP group outperforms the ADHD+LP group on all five outcome measures. This finding offers some support for the hypothesis of Tannock and Schachar (1996), in contrast to the results described earlier, in Section 7.1. The largest differences are on the measures for inhibition and non-verbal fluency. Both ADHD groups also have lower scores compared to the SLI group (264.76 for inhibition, see Table 6-2 and 1.71 for non-verbal fluency, see Table 6-6).

Executive functioning domain (outcome measure)	ADHD+RP (n=8)	ADHD-RP (n=18)
Inhibition (SSRT)	337.73 (73.73)	299.82 (68.88)
Working memory (SWM-be)	43.88 (7.64)	44.20 (13.29)
Planning (SOC-psm)	6.00 (1.51)	5.67 (2.19)
Cognitive flexibility (IED-68)	21.38 (10.86)	14.33 (10.49)
Non-verbal fluency (FPT-pp1)	9.79 (13.98)	5.37 (10.39)

Table 7-4: main outcome measures in the domain of executive functioning in means and SD (between brackets) for ADHD+RP and the ADHD-RP groups. MANOVA not significant, Wilks' Λ=.792, F(5,17)=.890, *p*>.05, η_p^2=.21. *Note* that three children from the ADHD+RP group are missing, due to missing SSRT data (see Sections 4.5.1 and 6.1.1)

7.2.2 ADHD children with reading problems

Comparing the main executive functioning scores of the children in the ADHD+RP group and in the ADHD-RP group with a MANOVA, there is no significant difference (Table 7-4).

When considering the raw figures of the ADHD+RP and ADHD-RP groups, the scores on the working memory and planning tasks are very similar. There are greater differences on the inhibition and non-verbal fluency tasks, with both groups scoring worse than the SLI children, but the ADHD+RP group worst of all. These findings resemble the findings is Section 7.2.1 with the ADHD+LP and ADHD-LP sub-groups, and can perhaps be explained by the considerable overlap between various sub-groups (see Section 5.7.2). On the cognitive flexibility task however, the ADHD+RP group clearly outperforms the ADHD-RP group. Moreover, the ADHD-RP group also does a little better than the SLI group (14.68, see Table 6-5). This was not the case for the ADHD+LP and ADHD-LP groups, and can, as of yet, not be explained.

In Section 7.3, we will first take a closer look at the performances within the three groups and within individual children (cf. Sections 5.5 and 6.2).

7.3 Comparisons of the language and executive functioning measures

In previous sections we compared the percentages of children in the three groups that scored badly, well or within the normal range in the two different domains, language and executive functioning (see Sections 5.5.1 and 6.2.1). These figures will be brought together in Section 7.3.1 to compare the results in the two domains. Section 7.3.2 considers individual performances in the two domains (see Sections 5.5.2 and 6.2.2). This is elaborated upon in Section 7.3.3,

where individual performance will be compared on three outcome measures that are relevant to the model by Tannock and Schachar (1996).

7.3.1 *Within-group comparisons*

Table 7-5 is a combination of totals from Table 5-11 and Table 6-7.

	ADH ≤-1	ADH ≈0	ADH ≥+1	SLI ≤-1	SLI ≈0	SLI ≥+1	TD ≤-1	TD ≈0	TD ≥+1
Lanugage	9%	82%	9%	36%	63%	1%	5%	74%	21%
EF	22%	68%	10%	14%	75%	11%	12%	66%	22%

Table 7-5: overview of total scores (percentages) within the ADHD, SLI and TD groups, with the five main outcome measures combined, per domain (language and executive functioning (EF)). Cf. Table 5-11 and Table 6-7

Comparisons at this general level underline the findings reported earlier in Sections 5.5.1 and 6.2.1. There are more SLI children with low scores in language and more ADHD children with low scores in executive functioning. There are more TD children with good scores in both domains. TD children have a higher percentage of below average scores for executive functioning outcomes than for language outcomes. This is probably a reflection of the fact that executive functioning develops later than language.

7.3.2 *Individual comparisons*

Table 7-6 is a combination of the totals from Table 5-12 and Table 6-8, and can be read in the same way, although the maximum number of scores is 10 instead of five.

Group +nr.	Nr. ≤-1	Nr. ≥+1	Group +nr.	Nr. ≤-1	Nr. ≥+1	Group +nr.	Nr. ≤-1	Nr. ≥+1
ADH1	0	1	SLI1	3	1	TD1	0	2
ADH2	1	0	SLI2	2	1	TD2	2	3
ADH3	3	2	SLI3	1	1	TD3	1	2
ADH4	0	1	SLI4	5	1	TD4	1	2
ADH5	0	2	SLI5	2	2	TD5	0	0
ADH6	0	2	SLI6	2	0	TD6	1	4
ADH7	2	0	SLI7	0	1	TD7	1	4
ADH8	0	1	SLI8	4	1	TD8	0	4
ADH9	1	1	SLI9	2	0	TD9	0	2
ADH10	6	0	SLI10	1	0	TD10	0	1
ADH11	1	2	SLI11	7	0	TD11	0	1
ADH12	2	1	SLI12	2	0	TD12	0	4
ADH13	6	0	SLI13	4	0	TD13	0	1
ADH14	3	1	SLI14	4	3	TD14	4	1
ADH15	0	1	SLI15	2	0	TD15	1	2
ADH16	0	1	SLI16	3	0	TD16	0	4
ADH17	0	0	SLI17	2	0	TD17	2	1
ADH18	1	0	SLI18	0	0	TD18	2	0
ADH19	0	2	SLI19	1	1	TD19	0	4
ADH20	1	1				TD20	0	3
ADH21	0	1				TD21	2	1
ADH22	3	1				TD22	2	1
ADH23	4	0						
ADH24	1	2						
ADH25	2	1						
ADH26	4	0						

Table 7-6: overview of scores of individual ADHD (n=26), SLI (n=19) and TD (n=22) children. In each column, the scores reflect poor (left-hand side) versus good (right-hand side) performance, based on counts of z-scores being equal to or more than 1 SD from the mean. This is counted over the five most important outcome measures in each domain, that of language and that of executive functioning (max.=10). Cf. Table 5-12 and Table 6-8

Table 7-7 is derived from the figures in Table 7-6. It shows the percentage of children in the ADHD, SLI and TD groups that score ≤-1 SD from the mean, that is, have a poor performance on either none of the 10 global outcomes, on four to six outcomes, or on six or more outcomes. The same options are also displayed for the scores that are ≥+1 SD from the mean. Thus, for example, the upper left cell reporting figures of the ADHD group shows that 59.5% of the ADHD children do not perform below average on any of the 10 tasks. On the other hand, 29% perform below average on two to four tasks, and the remaining 11.5% are below average on more than six tasks.

Scores	**ADH 0**	**ADH 2-4**	**ADH 6-10**	**SLI 0**	**SLI 2-4**	**SLI 6-10**	**TD 0**	**TD 2-4**	**TD 6-10**
≤-1SD from mean	59.5%	29%	11.5%	39.5%	45%	15.5%	70.5%	27.5%	2%
≥+1SD from mean	57.5%	42.5%	0%	76.5%	21%	2.5%	29.5%	59%	11.5%

Table 7-7: percentage of ADHD (n=26), SLI (n=19) and TD (n=22) children that score, respectively, 0/10, 2-4/10 or 6-10/10 times ≤-1 SD from the mean, and, likewise, ≥+1 SD from the mean

Table 7-7 shows that, when looking at the below-average scores, the ADHD and SLI children perform worse than the TD children. However, when comparing the ADHD and SLI groups, the SLI group is more impaired, i.e. has more scores in the 2-4 and 6-10 categories. Likewise, when looking at the above average scores, it is clear that the ADHD and SLI children perform worse than the TD children and that from the two clinical groups, the ADHD group outperforms the SLI group. However, in the ADHD group as well as in the SLI group (although in the latter less so than in the former), there are a substantial number of children that perform relatively well. This should be borne in mind alongside the poor performance.

7.3.3 Grammar and pragmatics in relation to executive functioning

Section 7.1 showed that there were no significant correlations between executive functioning and language measures, neither in the grammatical nor in the pragmatic domain. According to the model by Tannock and Schachar (1996), this was expected in the case of grammar, but not in the case of pragmatics.

In addition to the within-group and individual comparisons in the preceding sections, we now want to take a closer look at individual performances on the outcome measures that are of particular interest when evaluating the model by Tannock and Schachar (1996). That is, we will compare the most informative outcome measures, in the domain of executive functioning and in the domain of language (pragmatics and grammar). The decision which measures these are, is based on what we have found so far in this thesis, both in the literature part, and in the empirical part. We chose the measure of inhibition (SSRT) for the domain of executive functioning. For the domain of pragmatics, we chose the pragmatic composite of the children's communication checklist (PC-CCC) and for the domain of grammar, the percentage of morpho-syntactic errors in the frog-story (OMS-%). The z-scores of the children are again classified in either relatively bad (≤-1 SD below the mean), or relatively good performance (≥+1 SD equal to or above the mean). All other scores are considered normal (See Table 7-8).

Because the model by Tannock and Schachar (1996) seeks to explain performance in children with ADHD, the scores of the children with ADHD will be explored in most detail. Among the ADHD children, 17 out of 23 score in the normal range of SSRT scores. This unexpectedly good performance was discussed before (for example in Section 6.2.2). However, in comparison with the SLI and TD groups, the ADHD group still contains most children with lower than normal SSRT scores. Out of these six ADHD children,

two also have low PC-CCC scores, but the other four perform in the normal range.

A	SSRT	PC	OMS	SLI	SSRT	PC	OMS	TD	SSRT	PC	OMS
A1	0	0	0	S1	0	0	≤-1	T1	0	≥+1	0
A2	0	0	0	S2	0	0	≤-1	T2	0	≥+1	0
A3	-	≤-1	0	S3	≥+1	-	≤-1	T3	0	0	0
A4	0	0	0	S4	≤-1	0	≤-1	T4	0	0	0
A5	0	≥+1	0	S5	≥+1	0	0	T5	0	0	0
A6	0	0	0	S6	0	0	≤-1	T6	0	≥+1	≥+1
A7	-	0	0	S7	0	-	0	T7	0	≥+1	≥+1
A8	0	0	0	S8	≥+1	0	≤-1	T8	0	≥+1	0
A9	≤-1	0	0	S9	0	0	0	T9	≥+1	0	0
A10	≤-1	≤-1	0	S10	0	0	0	T10	0	0	0
A11	0	≤-1	0	S11	≤-1	≤-1	0	T11	0	0	0
A12	0	≤-1	0	S12	0	0	≤-1	T12	≥+1	≥+1	0
A13	≤-1	≤-1	0	S13	0	-	≤-1	T13	0	0	0
A14	≤-1	0	0	S14	0	-	≤-1	T14	≤-1	≥+1	0
A15	0	0	≥+1	S15	0	0	0	T15	0	≥+1	0
A16	0	0	0	S16	0	0	0	T16	≥+1	≥+1	0
A17	0	0	0	S17	0	-	≤-1	T17	0	0	0
A18	-	0	0	S18	0	0	0	T18	0	0	0
A19	0	0	0	S19	≥+1	0	0	T19	0	0	≥+1
A20	0	0	0					T20	0	0	0
A21	0	0	0					T21	≤-1	≥+1	0
A22	≤-1	0	0					T22	0	0	0
A23	≤-1	0	≤-1								
A24	0	≤-1	0								
A25	0	0	0								
A26	0	0	0								

Table 7-8: overview of scores (inhibition: SSRT; percentage of morpho-syntactic errors in the frog-story: OMS-%; pragmatic composite of the children's communication checklist: PC) of individual ADHD (A - n=23), SLI (S - n=14) and TD (T - n=22) children. ≤-1= z-score lower than or equal to 1 SD from the mean, ≥+1= z-score above or equal to 1 SD from the mean; 0= z-scores between 1 SD below and 1 SD above the mean; - =missing variable (see Section 4.5.1)

We expected that all children with inhibition problems would perform poorly on a measure for pragmatics. Furthermore, out of the same six children, one had an unexpectedly low OMS-% score, whereas five performed in the normal range. Not one of the six children had low scores in both language domains. These findings reflect the lack of significant partial correlations in Section 7.1 and thus fail to confirm Tannock and Schachar's model. We will come back to this issue in Section 8.3.

7.4 Summary of relation between language and executive functioning

This chapter focused on the third of the three research questions of this study, which was previously discussed in Sections 3.3 and 3.4:

Is there an association between executive functioning and language measures in children with ADHD, children with SLI and typically developing children?

Section 7.1 described the results of the partial correlations between the various executive functioning and language measures. Results from the ADHD, SLI and TD groups were taken together. Significant correlations were not found; neither between executive functioning and pragmatics, nor between executive functioning and grammar.

Section 7.2 elaborated on executive functioning in ADHD children with or without language problems as well as ADHD children with or without reading problems. Although not significantly so, the ADHD+LP group in general had worse executive functioning results than the ADHD-LP group, and likewise, than the SLI group. We found a similar pattern for the ADHD+RP and ADHD-RP groups.

Section 7.3 compared the measures at a within-group and at an individual level. At a within-group level, it was found that SLI

children's scores often were the worst for the language measures, and that ADHD children's scores often were the worst in the case of executive functioning scores. TD children's scores generally were the best, in both cases. At an individual level, and combining results of both language and executive functioning measures, it was found that the ADHD and SLI children performed worse than the TD children. Comparing the ADHD and SLI group, the latter group was generally impaired on more outcome measures.

The results from this study generally do not support the model by Tannock and Schachar (1996). The correlations between executive functioning and pragmatics, a key prediction from the model, were not significant (Section 7.1). When we looked at the individual children within the ADHD group, we did find that ADHD+LP children performed worse than ADHD-LP children on measures of executive functioning, although not significantly so (Section 7.2). This finding would be in favor of Tannock and Schachar's model. However, different language measures were used in these sections. In Section 7.1, the focus was on measures of pragmatics, and in Section 7.2, the focus was on more general language measures, encompassing both grammar and pragmatics. Tannock and Schachar (1996) speak specifically of the relationship of pragmatics and executive functioning, so the results from Section 7.1 are most informative, although more research with bigger groups is certainly necessary. The results from Section 7.2 might then be better explained in terms of double deficiencies, and the impact that these may have on other aspects of functioning.

8

Discussion and conclusion

Following the order of the three research questions of this study, first language, then executive functioning, and lastly the relation between these two will be discussed in Sections 8.1, 8.2 and 8.3 respectively. The impact of these findings will be explored, also in relation to methodological issues. Suggestions for further research will be made in Section 8.4.

8.1 Language

The current study is the first to assess in detail language abilities in children with ADHD in the Netherlands. Within the group of psychiatrically impaired children studied by Blankenstijn and Scheper (2003) were ADHD children, but they were not specifically identified. Moreover, Geurts (e.g. 2004a) did study ADHD children, but only used a general language questionnaire.

We found significant differences between the group of ADHD children and the SLI and TD groups. Leonard (2000; also see Section 2.1.2) argued for a characterization of language problems in terms of profile differences, rather than in terms of delay or deviance. A pattern of profile differences reflects a different degree of delay across features. This study did find profile differences across language domains. As expected on the basis of previous research, ADHD children were mainly impaired in pragmatics, whereas SLI

children were clearly impaired in both grammar and pragmatics. SLI is primarily associated with grammatical problems, but pragmatic problems were not unexpected (see Table 2-3 for an overview). Interestingly, the new, fifth version of the diagnostic statistical manual of mental disorders, which is currently being debated, proposes the 'social communication disorder'[41] as a new diagnosis. It encompasses persistent difficulties in pragmatics, across modalities, which affect social reciprocity. These should be present in early childhood and cause functional limitations. The pragmatic problems that were found in this study, both in the ADHD group and in the SLI group, would probably fit the criteria of this diagnosis, which is comparable to the diagnosis of 'pragmatic language impairment' that is used among speech language pathologists and clinical linguists (Bishop 2004, also see Section 2.1.2). The diagnosis in the DSM-5 would be welcome, because it would further enhance the awareness of the presence of language problems alone, or in addition to psychiatric impairments such as ADHD.

The grammar of children with ADHD was relatively spared in comparison with SLI children. SLI children, with their primary language problems, served as a benchmark for the secondary language problems of children with ADHD in this study. However, children in the ADHD group did have lower scores than children in the TD group on some grammatical outcome measures. Parigger (2010; using the same data of the same children as this study) examined four grammatical measures in more detail: the syntax scale score of the CCC-II-NL, the mean length of utterance in words in the frog story, the percentage of morpho-syntactic errors in the frog story, and the number of correct items on the sentence imitation

[41] See http://www.dsm5.org/proposedrevision/pages/proposedrevision.aspx?rid=489 (updated May, 1, 2012).

task. ADHD children had significantly lower scores than TD children on the first two, but not on the last two outcome measures. Moreover, 54% of the children with ADHD fell short on one or more of these measures, as opposed to 23% of the TD children. For 8% of the ADHD children, the problems were robust, that is, evident in all four measures. This was the not the case for any of the TD children. In other words, individual ADHD children certainly can have grammatical problems, and these were sometimes masked by the group evaluations.

In order to explore the possibility that ADHD children fall into two groups, those with and those without language problems, we divided the ADHD group into two such subgroups. Previous studies have taken this approach at the outset of their research. We defined language problems in the ADHD group on the basis of two general language measures: the number of correctly repeated items of the sentence imitation test and the general communication composite of the language questionnaire. ADHD children who were performing below the cut-off on one or on both of these outcome measures were considered to have language problems. This resulted in a subgroup of 14 ADHD children with language problems (54%) and a subgroup of 12 ADHD children without language problems (46%). The ADHD subgroups were small, making it difficult to obtain significant results in a comparison of these two groups. In general, it must be concluded that there is no neat division between the two sub-groups on the outcome measures of the frog story and the non-word repetition task. Future research should thus make use of bigger sub-groups.

8.2 Executive functioning

Executive dysfunctions are seen in various disorders, not only in ADHD. Therefore, it is unclear how specific to a disorder executive

functioning deficits are. Pennington and Ozonoff (1996) already pointed to this 'discriminant validity problem', which was more elaborately discussed in Section 3.2. A possible solution to the problem would be to look for profile and level differences. That is, children with a specific disorder might be performing well on some executive functions, and poorly on others. Moreover, the severity of the impairment, thus per executive function, might differ across children with different disorders (cf. Leonard, 2000 – also discussed in the previous section).

This study examined the performance of children with ADHD and children with SLI on five executive functions measured non-verbally. This comparison had not been made before. A profile difference was found. ADHD children performed poorly on inhibition but well on working memory, planning, cognitive flexibility and fluency. SLI children did not show problems on any of the five aspects of executive functioning. On the basis of the literature, we expected to find problems with inhibition in the ADHD group (Section 3.2.1). We also expected to find problems in the SLI group, although this expectation was based on only a few available studies (Section 3.2.2). The result for the SLI children may be due to several factors. Of the studies discussed, most involved older children, possibly implying a more severe form of language impairment. Moreover, different tasks were used. Henry, et al. (2012) for example used the hand-fist Luria task, a task rather different from the SST task used here. Further research is thus necessary to investigate possible problems with inhibition in SLI children and to compare their performance to that of ADHD children.

There is considerable discussion in the literature on the use of different measures for executive functioning. Differences are found between clinical and typically developing groups, but it is still a question of further research as to whether these differences can be interpreted as a problem with an executive function or as a problem

with a certain task. In a critical review of cognitive flexibility tasks for example, Geurts, Corbett and Solomon (2009) highlight the discrepancy between the observation of inflexible everyday behaviors in autistic children on the one hand and the lack of consistent evidence for cognitive flexibility deficits from experimental tasks on the other.

8.3 Language and executive functioning

An association between pragmatic language problems and problems with executive functioning, as predicted by Tannock and Schachar's model (1996), was not found. The model could therefore not be supported.

The question of overlap between symptoms of inattention/ hyperactivity-impulsivity, language problems and/or reading problems was discussed in Section 5.7.2. The large amount of overlap as found in this study was expected on the basis of the literature (also see Section 2.3 and, in particular, Figure 2-1). Although we did not report on this overlap in relation to executive functioning, we will briefly explore the issue here. A look at the SSRT scores of the inhibition subtest shows that out of the eight children with a score equal to or more than one SD below the mean, only one belonged to the ADHD-only group. Two were in the ADHD group with language problems, and one more was in the group with language and reading problems. However, four were in the ADHD group with both language problems and reading problems. Clearly, clustering of various symptoms is fairly common and we know that children with clustered problems are generally more impaired (e.g. Leonard, 2000). The question thus arises what the status of each label is, and this will have to be addressed in future research. Qualitative analyses will also be important, because then, as we have seen, quantitative analyses can easily mask individual differences.

In contrast to children with a cluster of problems, there were also children in this study who were performing relatively well, and only showed symptoms of one or two of the four domains presented above (symptoms of inattention/hyperactivity-impulsivity, language problems, reading problems, executive dysfunctioning). For example, half of the ADHD children had no problems with executive functioning at all. Sonuga-Barke (e.g. 2002; 2003; 2005, also see Section 6.2.2) already concluded that executive dysfunctioning alone cannot explain ADHD and proposed multiple developmental pathways to ADHD. Instead of executive functioning, other underlying processes, such as reward processing, may also play a role in the development of ADHD. Environmental factors are probably important as well. For example, Pelsser (2011) reported a rather large effect of a restricted elimination diet on symptoms of ADHD. If it is indeed the case that other factors than executive functioning can cause ADHD, it is not surprising that we found ADHD children without signs of executive functioning problems and also without pragmatic language problems. This could also be predicted by Tannock and Schachar (1996). However, the presence of ADHD children with executive dysfunctioning problems but without pragmatic problems, or, even more problematic, without executive dysfunctioning problems but with pragmatic language problems, cannot be explained. These cases constitute further evidence against their model.

8.4 Implications and further research

The results of this study clearly show that a clustering of problems can occur in ADHD children. More attention must be paid to the co-occurrence of ADHD and language/reading problems in clinical practice. In the Netherlands, this is generally not the case. A child with inattention/hyperactivity-impulsivity symptoms will go to a

psychiatrist and/or psychologist. On the other hand, a child with language and/or reading problems will visit a clinical linguist and/or speech-language therapist. These are two separate diagnostic and treatment channels. The most salient problems initially get the most attention and the focus tends to remain on the one type of problem since the child usually stays within one channel. There are only a few places, for the most complicated cases, where the two disciplines work together. An interdisciplinary approach should be more common, also for less severe cases. In the case of a child with ADHD underperforming in class, the teacher is likely to attribute this to the symptoms of inattention and/or hyperactivity-impulsivity. The child could be helped more adequately if the poor school performance could be also related to co-morbid language and/or reading problems.

In the discussion of the above issues, suggestions have been made for future research. In addition, Karmiloff-Smith (1998) already pointed out that different disorders might be considered to lie on a continuum rather than to be truly specific. This is applicable to both the ADHD and SLI children in this study. Karmiloff-Smith therefore proposed that:

'*Rather than concentrate on the study of disorders solely at their end state in school-aged children and adults, which is most commonly the case, it becomes essential to study disorders in early infancy, and longitudinally, to understand how alternative developmental pathways might lead to different phenotypical outcomes.*' (Karmiloff-Smith, 1998: 397)

This proposal needs to be taken more seriously in future work.

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Summary

Children with ADHD can be characterized by their behavioural symptoms, such as inattention, hyperactivity and/or impulsivity. However, there is more to ADHD than these symptoms. In fact, there is some evidence from research that these children also have problems with language. The first aim of this thesis was to examine the language abilities of ADHD children in more detail and to compare them to children who are known to have language problems, namely children with specific language impairment (SLI).

Children with ADHD also often have problems in executive functioning, an umbrella term for various higher order cognitive processes, responsible for goal-directed behaviour. Executive functioning in children with SLI has only recently become a topic of interest, although the diagnosis presupposes that there is no known aetiology for their language problems. Therefore, the second aim of the study was to examine and compare executive functioning in both ADHD and SLI children.

Executive dysfunctioning is possibly linked to problems with language. This link has to date not been empirically demonstrated in typically developing children (TD). Work on children with SLI has concentrated more on exploring whether executive functioning problems exist, rather than seeking an explanation for the language problems in such dysfunctioning. On the other hand, Tannock and Schachar (1996) have proposed that both the behavioural and the

(mainly pragmatic – see below) language problems of children with ADHD are caused by underlying deficits in executive functioning. Consequently, the third and last aim of this study was to explore this possibility in both groups of children.

The three main goals of this thesis, described above, were introduced in Chapter 1. Chapters 2 and 3 provided a further background to the study.

Chapter 2 reviewed the literature about language in children with ADHD and in children with SLI. The SLI group served in this thesis as a benchmark for the ADHD group with respect to language. By definition, language comprehension and production is impaired in children with SLI and this is clearly the case across all language domains. However, problems are sometimes more evident in one domain than another. Children with so-called 'typical SLI' (Bishop, 2004), the group of interest in this study, experience most problems in the domain of grammar.

There was less literature available about language in children with ADHD. Mild problems in pragmatic language comprehension have been reported. On the productive side, specific, but not very severe problems in phonology, lexicon and grammar also occur. However, language problems of children with ADHD are most notable in the domain of productive pragmatics. For example, they often have difficulties telling a story coherently, and can introduce protagonists using only pronouns - assuming that the listener knows who they are talking about. Very few studies have compared the language problems of ADHD and SLI children, and, as a consequence, no detailed contrastive profile has to date emerged. The chapter concluded with a brief discussion of the literature on symptom overlap. The association between ADHD and (S)LI is above chance. Moreover, reading problems frequently occur, both in ADHD and in SLI. Therefore, it was decided that problems with reading also had to be assessed in this study.

Chapter 3 focused on the literature about non-verbal executive functioning in children with ADHD and in children with SLI. Five executive functions were reviewed, following the well-known taxonomy by Pennington and Ozonoff (1996). These were inhibition, working memory, planning, cognitive flexibility and fluency. All studies about children with ADHD point to a problem with inhibition. Problems with the other four functions have also been reported, but not consistently so. Only relatively few studies have reported on executive functioning in SLI. Tentatively, we concluded that problems with inhibition were more common than problems with working memory, planning, cognitive flexibility and fluency. It remained unclear, both in ADHD and in SLI, how specific the executive functioning deficits are, and whether or not profile and level differences can be distinguished. Pennington and Ozonoff also referred to this problem, coining it 'the discriminant validity problem'. The chapter then discussed executive functioning in relation to language and, more specifically, the proposal by Tannock and Schachar (1996), mentioned above, that executive dysfunctioning may account for both the behavioural and the pragmatic language problems of children with ADHD. We decided to explore the issue in this study, and additionally, to extend it to executive functioning in relation to language in children with SLI. The chapter concluded with the research questions and general hypotheses.

Chapter 4 described the research method. All children selected were in the age range of 7;0 to 8;11. The mean age was 8;2. Moreover, they were monolingual Dutch. Children that had problems not associated with the symptomatology of either ADHD or SLI were excluded from the study. The SLI children had been diagnosed as 'typical SLI', with predominantly grammatical problems. Children with speech output problems were excluded, and the cut-off point for non-verbal intelligence was set at 80. The

diagnoses of the ADHD children were also checked very carefully. Only children from the combined and from the mainly hyperactive subtypes were included. Co-morbidity of oppositional defiant disorder and conduct disorder was allowed, but monitored with a questionnaire assessing externalizing symptoms, also including ADHD symptoms. Co-morbidity of reading problems was assessed with (non-)word reading tasks. There were 22 children in the TD group, 19 in the SLI group and 26 in the ADHD group.

The children were tested three times. In the first session, they completed a non-verbal intelligence test. The second and third sessions were counterbalanced and focused on langage and executive functioning. The language battery included a narrative, elicited with the picture book *Frog, were are you?* (Mayer, 1969). Various grammatical and pragmatic variables were coded in the transcripts. Moreover, the children performed a non-word repetition and a sentence imitation task, and the parents of the children completed the CCC-II-NL, a questionnaire assessing language abilities, focusing in particular on pragmatics. The neuropsychological battery assessed non-verbal executive functioning. Inhibition, working memory, planning, and cognitive flexibility were tested with the CANTAB, an automated testing battery. Fluency was tested with a paper-and-pencil task (see Tables 4-4 and 4-5 for a complete overview of the variables). The results were statistically analyzed (controlling for differences in non-verintelligence) with the help of SPSS.

The results were presented in Chapters 5 to 7. Chapter 5 reported results of the language measures, Chapter 6 reported results of the executive functioning measures and Chapter 7 explored the relation between the language results and the executive functioning results.

Children with ADHD were found to differ significantly in language production in comparison with typically developing children, most notably so when looking at pragmatics. Moreover,

the ADHD group could be differentiated from the SLI group since they did better on phonological and grammatical measures. However, in the case of pragmatics, there was less of a difference between the two clinical groups, both performing more poorly than the typically developing group. These findings were reflected also in within-group and individual comparisons (raw scores). Moreover, a considerable overlap was found for symptoms of inattention/hyperactivity-impulsivity, language problems and reading problems (Chapter 5).

With respect to executive functioning, children with ADHD performed significantly worse than SLI and TD children only on the measure for inhibition. No differences between these three groups were reported for working memory, planning, cognitive flexibility and non-verbal fluency. However, within-group and individual comparisons generally showed that ADHD children had the worst scores, TD children had the best scores, and that SLI children's scores fell somewhere in between (raw scores). These comparisons also showed that about half of the ADHD group performed relatively well on executive functioning tasks, and we concluded, as others have done (cf. Sonuga-Barke, 2005), that executive dysfunctioning alone cannot account for all of the ADHD symptoms (Chapter 6).

In order to explore the link between executive functioning and language, results of the three groups were taken together and correlations were calculated. Significant correlations were not found; not between executive functioning and pragmatics, and not between executive functioning and grammar. We decided to take a closer look and compared ADHD children with language problems to ADHD children without language problems. In general, the ADHD group with language problems had worse executive functioning scores than the ADHD group without language problems, and likewise, than the SLI group. However, the differences between the groups were not significant and therefore it had to be concluded that the model of

Tannock and Schachar (1996) could not be supported by the results of this study (Chapter 7).
The concluding discussion in Chapter 8 again focused on language, executive functioning, and the link between these two, on the basis of findings from the literature (2-3) and result (5-7) chapters.

Firstly, the profile differences that we found across language domains were discussed (Leonard, 2000). ADHD children were mainly impaired in pragmatics, whereas SLI children were impaired in both grammar and pragmatics.

The pragmatic problems that were found in this study, both in the ADHD group and in the SLI group, would probably fit the criteria of the 'social communication disorder', a new diagnosis in the DSM-5. We welcome this diagnosis, because it would further enhance the awareness of pragmatic language problems, occurring as part of the SLI symptomatology, or in addition to psychiatric impairments such as ADHD. On the other hand, the grammar of children with ADHD was relatively spared in comparison with SLI children. However, children in the ADHD group did have lower scores than children in the TD group on some grammatical outcome measures. In other words, individual ADHD children could certainly have grammatical problems, and these were sometimes masked by the group evaluations.

Secondly, we discussed executive functioning, and in particular the 'discriminant validity problem'. As mentioned above, the assumption of profile differences could be a solution to this problem (Pennington and Ozonoff, 1996). This study did find a profile difference: children with ADHD performed poorly on inhibition in comparison with SLI children, although we expected on the basis of the literature that we would find inhibitory problems in both groups. The result for the SLI children may be due to several factors. Of the studies discussed, most involved older children, possibly implying a more severe form of language impairment.

Moreover, different tasks were used. Further research is thus necessary to investigate possible problems with inhibition in SLI children and to compare their performance to that of ADHD children.

Thirdly, a specific association between pragmatic language problems and problems with executive functioning, as predicted by the model of Tannock and Schachar (1996), was not found. The model could therefore not be supported. Looking at individual scores however, we found that problems with executive functioning were more common in children who also exhibited symptoms of inattention/hyperactivity-impulsivity, language problems and reading problems. This clustering of symptoms should get more attention in clinical practice as well as in future research. In clinical practice because children with clustered symptoms tend to be more severely impaired (e.g. Leonard, 2000); treatment aimed at all symptoms instead of just one or two might enhance their functioning. In future research, a longitudional perspective is preferable, to study from early infancy onward how alternative developmental pathways might lead to particular phenotypical outcomes (see also Karmiloff-Smith, 1998).

Samenvatting

Kinderen met ADHD zijn te herkennen aan bepaalde gedragssymptomen, zoals onoplettendheid, hyperactiviteit en/of impulsiviteit. Maar ADHD is meer dan deze symptomen alleen. Uit sommig onderzoek komt naar voren dat deze kinderen ook taalproblemen kunnen hebben. Het eerste doel van deze studie was dan ook om de taalvaardigheid van kinderen met ADHD uitgebreider te onderzoeken en om ze te vergelijken met kinderen van wie al bekend is dat ze taalproblemen hebben, namelijk kinderen met SLI ('specific language impairment').

Kinderen met ADHD hebben vaak ook problemen op het gebied van executief functioneren. Met executief functioneren wordt een een aantal cognitieve processen bedoeld die samen verantwoordelijk zijn voor doelgericht gedrag. Het executief functioneren van kinderen met SLI is pas recentelijk in de belangstelling komen te staan, al vooronderstelt de diagnose dat er geen aanwijsbare oorzaken zijn voor hun taalproblemen. Het tweede doel van deze studie was dan ook het executief functioneren van kinderen met ADHD en van kinderen met SLI te onderzoeken en vergelijken.

Er is mogelijk een verband tussen executief disfunctioneren en taalproblemen. Dit verband is tot op heden niet empirisch aangetoond bij kinderen die zich normaal ontwikkelen. Het onderzoek naar kinderen met SLI heeft zich vooral geconcentreerd op de vraag of er problemen zijn met het executief functioneren, in

plaats van op de vraag of dergelijke problemen een verklaring zouden kunnen zijn voor hun taalproblemen. Tannock en Schachar (1996) gaan er echter vanuit dat zowel de gedragsproblemen als de (met name pragmatische – zie hieronder) taalproblemen van kinderen met ADHD worden veroorzaakt door onderliggend executief disfunctioneren. Het onderzoeken van deze hypothese, bij beide groepen kinderen, was het derde en laatste doel van deze studie.

De drie belangrijkste doelen van dit proefschrift, zoals hierboven omschreven, werden geïntroduceerd in hoofdstuk 1. Hoofdstukken 2 en 3 gingen dieper in op de achtergronden van deze studie.

Hoofdstuk 2 gaf een overzicht van de literatuur over taal bij kinderen met ADHD en bij kinderen met SLI. De SLI-groep diende in dit proefschrift als toetssteen, wat taal betreft, voor de ADHD-groep. Bij kinderen met SLI zijn het taalbegrip en de taalproductie per definitie problematisch en dat geldt voor alle taaldomeinen. De problemen zijn soms echter duidelijker in het ene taaldomein dan in het andere. Kinderen met zogenaamde 'typische SLI' (Bishop, 2004), de groep waar deze studie zich op richtte, ervaren vooral problemen op het gebied van de grammatica.

Er is minder literatuur over de taalvaardigheid van kinderen met ADHD. Soms worden milde problemen met pragmatisch taalbegrip vermeld en wat betreft taalproductie komen ook specifiekere, maar niet al te ernstige problemen voor op het gebied van fonologie, woordenschat en grammatica. De taalproblemen van kinderen met ADHD zijn evenwel het duidelijkst op het gebied van de productieve pragmatiek. Ze vinden het bijvoorbeeld vaak moeilijk om een verhaal op een coherente manier te vertellen en soms introduceren ze personages door alleen een persoonlijk voornaamwoord te gebruiken, waarbij ze ervan uitgaan dat de luisteraar begrijpt wie ze bedoelen. Verder zijn er maar heel weinig studies die de taalproblemen van ADHD- en SLI-kinderen hebben vergeleken. Een

onderscheidend taalprofiel is voor deze groepen dan ook nog niet beschreven. Het hoofdstuk eindigde met een korte discussie van de literatuur over symptoomoverlap. ADHD- en (S)LI-symptomen komen vaker samen voor dan verwacht zou worden op basis van kansberekening. Bovendien komen zowel bij ADHD- als bij SLI-kinderen veelvuldig leesproblemen voor. Daarom werd besloten om ook leesproblemen mee te nemen in deze studie.

Hoofdstuk 3 behandelde de literatuur over non-verbaal executief functioneren van kinderen met ADHD en van kinderen met SLI. Vijf executieve functies werden bekeken, die waren gekozen naar aanleiding van de bekende taxonomie van Pennington en Ozonoff (1996). Het ging om inhibitie, werkgeheugen, planning, cognitieve flexibiliteit en vloeiendheid. Alle onderzoeken wijzen uit dat inhibitie een problematische functie is voor kinderen met ADHD. Problemen met de andere vier functies worden ook gemeld, maar minder consistent. Slechts een klein aantal studies behandelt executief functioneren bij SLI. Naar aanleiding van deze studies concludeerden we voorzichtig dat problemen met inhibitie meer voorkomen bij kinderen met SLI dan problemen met werkgeheugen, planning, cognitieve flexibiliteit en vloeiendheid. Het blijft echter onduidelijk, zowel bij ADHD als bij SLI, hoe specifiek de executieve functieproblemen zijn en of er al dan niet profiel- en niveauverschillen kunnen worden onderscheiden. Pennington en Ozonoff wezen ook al op dit probleem en verwezen ernaar als het 'discriminant validity problem'. Vervolgens ging het hoofdstuk dieper in op executief functioneren in relatie tot taal en meer specifiek op het idee van Tannock en Schachar (1996), zoals hierboven al beschreven, dat executief disfunctioneren verantwoordelijk is voor zowel de gedragsproblemen als de pragmatische taalproblemen van kinderen met ADHD. We besloten om dit verder te onderzoeken in deze studie en om bovendien het executief functioneren in relatie tot taalvaardigheid van kinderen met

SLI te onderzoeken. Het hoofdstuk eindigde met de onderzoeksvragen en de algemene hypotheses.
In hoofdstuk 4 kwam de onderzoeksmethode aan bod. Alle geselecteerde kinderen hadden een leeftijd tussen 7;0 en 8;11 jaar. De gemiddelde leeftijd was 8;2 jaar. Bovendien hadden ze Nederlands als moedertaal en spraken ze daarnaast geen andere taal. Kinderen die problemen hadden die niet passen bij de symptomatologie van of ADHD of SLI werden uitgesloten van de studie. De SLI-kinderen waren gediagnosticeerd als 'typical SLI', en hadden dus vooral grammaticale problemen. Kinderen die ook spraakproblemen hadden, werden uitgesloten, en de ondergrens voor non-verbale intelligentie was 80. De diagnoses van de ADHD-kinderen werden nauwkeurig gecheckt. Alleen kinderen van de gecombineerde en overwegend hyperactieve subtypes werden in het onderzoek betrokken. Comorbide (oppositioneel opstandige) gedragsstoornissen waren toegestaan, maar werden gemonitord met een vragenlijst die externaliserende symptomen toetst, waaronder ook ADHD-symptomen. Comorbiditeit van leesproblemen werd bepaald aan de hand van (non-)woord leestaken. Er zaten 22 kinderen in de zich normaal ontwikkelende groep, 19 in de SLI-groep en 26 in de ADHD-groep.

De kinderen werden drie keer getest. Tijdens de eerste sessie deden ze een non-verbale intelligentietest. De tweede en derde sessie richtten zich afwisselend op taal of executief functioneren. Het taalonderzoek bestond onder meer uit het vertellen van een verhaal, uitgelokt met behulp van het prentenboek *Frog, where are you?* (Mayer, 1969). Verschillende grammaticale en pragmatische variabelen werden gecodeerd in de transcripten. Bovendien voerden de kinderen een non-woordrepetitietaak en een zinsimitatietaak uit en vulden hun ouders de CCC-II-NL in, een vragenlijst die taalvaardigheid in kaart brengt en die zich met name richt op pragmatiek. Het neuropsychologisch onderzoek toetste niet-verbaal

executief functioneren. Inhibitie, werkgeheugen, planning en cognitieve flexibiliteit werden onderzocht met behulp van de CANTAB, een geautomatiseerde testbatterij. Vloeiendheid werd getest met een meer traditionele taak op papier (zie tabellen 4-4 en 4-5 voor een compleet overzicht van de variabelen). De resultaten werden statistisch geanalyseerd (waarbij gecontroleerd werd voor verschillen in non-verbale intelligentie) met behulp van SPSS.

De resultaten werden gepresenteerd in de hoofdstukken 5 tot en met 7. Hoofdstuk 5 besprak de resultaten die betrekking hadden op taal, en hoofdstuk 6 de resultaten die betrekking hadden op executief functioneren. Hoofdstuk 7 verkende de relatie tussen beide soorten resultaten.

De taalproductie van kinderen met ADHD bleek significant te verschillen van die van zich normaal ontwikkelende kinderen, vooral op het gebied van de pragmatiek. Bovendien kon de ADHD-groep worden onderscheiden van de SLI-groep. De ADHD-kinderen scoorden beter op verschillende fonologische en grammaticale variabelen. Op het gebied van de pragmatiek was er echter minder verschil tussen de beide groepen, die het allebei slechter deden dan de zich normaal ontwikkelende groep. Deze uitkomsten werden bevestigd door vergelijkingen binnen de groepen en door individuele vergelijkingen (ruwe scores). Bovendien was er een aanzienlijke overlap tussen symptomen van onoplettendheid/hyperactiviteit-impulsiviteit, taalproblemen en leesproblemen.

Wat betreft executief functioneren, scoorden kinderen met ADHD alleen op inhibitie significant slechter dan SLI- en zich normaal ontwikkelende kinderen. Tussen de drie groepen werden geen verschillen gevonden in werkgeheugen, planning, cognitieve flexibiliteit en vloeiendheid. Vergelijkingen binnen de groepen en tussen individuele kinderen lieten echter wel zien dat de ADHD-kinderen meestal het laagst scoorden, de zich normaal ontwikkelende

kinderen het hoogst en de SLI-kinderen daar ergens tussenin (ruwe scores). Ook werd zo aangetoond dat ongeveer de helft van de ADHD-groep het eigenlijk relatief goed deed op de executieve functietaken. We concludeerden dan ook, net als anderen voor ons (bv. Sonuga-Barke, 2005), dat executief disfunctioneren alléén niet verantwoordelijk kan zijn voor alle ADHD-symptomen (hoofdstuk 6).

Om het verband tussen executief functioneren en taal nader te onderzoeken, namen we de resultaten van de drie groepen samen en berekenden we correlaties. Er werden geen significante correlaties gevonden, noch tussen executief functioneren en pragmatiek, noch tussen executief functioneren en grammatica. We besloten hier dieper op in te gaan en ADHD-kinderen met taalproblemen te vergelijken met ADHD-kinderen zonder taalproblemen. In het algemeen had de ADHD-groep met taalproblemen lagere executieve functiescores dan de ADHD-groep zonder taalproblemen, en ook lagere scores dan de SLI-groep. Omdat de verschillen tussen deze groepen echter niet significant waren, moesten we toch concluderen dat het model van Tannock en Schachar (1996) niet wordt ondersteund door de resultaten van deze studie (hoofdstuk 7).

De slotdiscussie in hoofdstuk 8 richtte zich wederom op taal, executief functioneren en het verband daartussen, op basis van de gegevens uit de hoofdstukken over de literatuur (2-3) en over de resultaten (5-7).

Ten eerste werden de profielverschillen in de taaldomeinen behandeld (Leonard, 2000). ADHD-kinderen ondervonden vooral problemen met pragmatiek, terwijl SLI-kinderen zowel problemen hadden met grammatica als met pragmatiek.

De pragmatische problemen die deze studie aan het licht bracht, zowel bij de ADHD-groep als bij de SLI-groep, voldoen waarschijnlijk aan de criteria van de 'social communication disorder', een nieuwe diagnose in de DSM-5. Deze diagnose kan mensen meer bewust maken van pragmatische taalproblemen, als

onderdeel van de SLI-symptomatologie, of in aanvulling op psychiatrische diagnoses zoals ADHD. De grammatica van ADHD-kinderen was relatief goed vergeleken met die van de SLI-kinderen. Kinderen uit de ADHD-groep behaalden echter wel lagere scores dan zich normaal ontwikkelende kinderen op sommige grammaticale variabelen. Met andere woorden, individuele ADHD-kinderen konden zeker grammaticale problemen hebben, maar die werden soms gemaskeerd in groepsvergelijkingen.

Ten tweede bespraken we executief functioneren, en in het bijzonder het 'discriminant validity problem'. Zoals gezegd zou het uitgaan van profielverschillen een oplossing kunnen bieden voor dit probleem (Pennington en Ozonoff, 1996). Uit deze studie kwam inderdaad een profielverschil naar voren: kinderen met ADHD presteerden in vergelijking met SLI-kinderen slecht op inhibitie, hoewel we op basis van de literatuur hadden verwacht dat we bij beide groepen inhibitieproblemen zouden aantreffen. Aan de scores van de SLI-kinderen kunnen verschillende factoren ten grondslag liggen. De meeste literatuurstudies die we hebben besproken, gingen over oudere kinderen, die daarom wellicht een ernstiger taalstoornis hadden. Bovendien werden verschillende taken gebruikt. Verder onderzoek is dus nodig om mogelijke problemen met inhibitie bij SLI-kinderen aan het licht te brengen en om hun prestaties te vergelijken met die van ADHD-kinderen.

Ten derde werd een specifieke associatie tussen pragmatische taalproblemen en executief functioneren, zoals voorspeld door Tannock en Schachar (1996), niet gevonden. Hun model kon derhalve niet worden ondersteund. Als we echter keken naar individuele scores, dan zagen we wel dat problemen met executief functioneren meer voorkwamen bij kinderen die ook symptomen hadden van onoplettendheid/hyperactiviteit-impulsiviteit, taalproblemen en leesproblemen. Deze clustering van symptomen zou meer aandacht moeten krijgen, zowel in de klinische praktijk als in verder

wetenschappelijk onderzoek. Kinderen met geclusterde symptomen zijn meestal beperkter in hun functioneren (bv. Leonard, 2000), en wellicht zou een behandeling die gericht is op alle symptomen in plaats van slechts een of twee meer soelaas bieden. Bij toekomstig onderzoek zou een longitudinaal perspectief te verkiezen zijn, om zo vanaf de vroege kindertijd te kunnen bestuderen hoe verschillende ontwikkelingen tot specifieke fenotypische uitkomsten leiden (zie ook Karmiloff-Smith, 1998).

Curriculum vitae

Esther Mariëlla Parigger was born on April 13th, 1975 in Alkmaar, the Netherlands. In 1994, she completed her high school education at the Murmellius Gymnasium, and then started at the University of Amsterdam with a propedeuse in Spanish Language and Culture. She continued to complete an MA in General Linguistics in 2000 and later an MA in Psychology in 2004. She then started work on her PhD-thesis. Parallel to her studies, from 2001 until 2004 she worked as a research assistant and junior project leader at the R&D department of the Institute of the Deaf in Sint Michielsgestel, and as a clinical child psychologist in outpatient clinics in Haarlem and Hoofddorp from 2003 until 2009. From 2005 to 2008 she taught speech/language development and pathology at the University of Amsterdam, and from 2009 to 2012 she worked as senior researcher at the R&D department of Interhealth in Dordrecht. She currently works as a lecturer at the Psychology department of the Amsterdam University of Applied Sciences.