Language and executive functioning in children with ADHD
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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. 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.

\footnote{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.

Comprehension

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

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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.

Production
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 a 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. 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

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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 MLU5, 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). 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).

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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.

\(^7\) 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.

**Comprehension**

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 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.

![Venn diagram of overlap between symptoms of inattention/ hyperactivity-impulsivity, language problems and reading problems](image)

**Figure 2-1: Venn diagram of overlap between symptoms of inattention/ hyperactivity-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) 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.

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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.

<table>
<thead>
<tr>
<th>Language</th>
<th>SLI</th>
<th>ADHD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comprehension</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phonology</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Lexicon</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Morpho-syntax</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Pragmatics</td>
<td>+</td>
<td>+/- (i.e. inferential questions)</td>
</tr>
<tr>
<td>Production</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phonology</td>
<td>+</td>
<td>+/- (i.e. articulation)</td>
</tr>
<tr>
<td>Lexicon</td>
<td>+</td>
<td>+/- (i.e delayed onset)</td>
</tr>
<tr>
<td>Morpho-syntax</td>
<td>++</td>
<td>+/- (i.e. sentence imitation/mazes)</td>
</tr>
<tr>
<td>Pragmatics</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

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:

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

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.