UNIVERSITY OF AGDER

Two mechanisms or one?

A comparison of past tense acquisition in children with specific language impairment and typically developing children

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This master's thesis is carried out as a part of the education at the University of Agder and is therefore approved as a part of this education. However, this does not imply that the University answers for the methods that are used or the conclusions that are drawn.

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1. Introduction

How children acquire language might seem like a mystery. Children who are still in diapers interpret sequences of sounds as meaningful words and within a few years produce grammatically complex sentences. Child language acquisition starts at such an early age that we often take the ability to speak for granted. However, for some children the skill is not acquired without effort. About 7% of children have a significant limitation in language ability without any apparent explanation (Leonard 1998). The disorder is known as Specific Language Impairment.

In this thesis I will give a linguistically motivated analysis of Specific Language Impairment (SLI). I hope to discover whether knowledge of SLI might shed light on child language acquisition. For decades researchers have debated whether children have an innate ability to help them acquire grammatical rules. Two schools of theory have proposed arguments for (generativists) and against (constructivist) this claim. My aim is to investigate whether research on SLI might reveal how children acquire knowledge of morphological rules. Is it according to the generativist or the constructivist approach?

My approach to answer this question is by comparing studies on regular and impaired past tense acquisition. I want to discover whether empirical results are according to the generativists or constructivist model. In chapter 2, I will start by introducing the two schools of theory and compare their approaches to regular language acquisition. I will also give a brief description of how children typically acquire language. Chapter 3 describes causes, diagnostic criteria and language characteristics of children with specific language impairment. I aim to discover how SLI children's language production deviates from regular language production.

Chapter 4, 5 and 6 describe empirical studies of impaired and regular production of one linguistic feature, past tense inflection. I consider past tense morphology in English to be a suitable topic for the debate on an innate rule-mechanism because there are two forms of English past tense, regular and irregular verbs. Studies of past tense production can reveal whether regulars and irregulars are formed by two separate mechanisms (cf. section 2.1.1 generativist approach), or if all past tense forms are generated by the same mechanism (cf. section 2.1.2 constructivist approach).

Research on past tense production has revealed that constructivists and generativists interpret empirical results differently. In chapter 4 I will present how *overgeneralization errors* (cf. section 4.1) are interpreted by the constructivist camp, Rumelhart & McClelland (1986) and Ramscar (2002), and the generativist camp, Pinker and Prince (1988) and Marcus et al. (1992).

In chapter 5 I will consider central studies on acquisition of inflectional morphology (cf. section 5.1) and studies comparing impaired and regular past tense production (cf. section 5.2.1-4). The studies on impaired acquisition have different approaches to the topic. Marchman et al. (1999) consider the influence of frequency and phonology in regularly developing and SLI children's production of past tense (cf. section 5.2.1). Serratrice et al. (2003) describe the use of regular and irregular past tense before and after the onset of overregularization (cf. section 5.2.2). Both, Ullman & Van der Lely (2001) and Maillart & Schelstraete (2002), want to discover whether SLI is an input-processing deficit or a grammar specific deficit. Generativists, Ullman and Van der Lely (2001) argue that SLI is an impairment in grammatical computation (cf. section 5.2.3). However, constructivists, Maillart and Scelstraete (2002) claim that SLI is an input-processing deficit caused by impaired working memory (cf. section 5.2.4.1). How both generativists and constructivists find empirical results to support their hypothesis will be discussed in chapter 7.

Chapter 6 presents two studies on the biological foundations of SLI. In this chapter I want to discover whether biological entities, such as genetic influence (cf. section 6.1) and neural activation in different brain regions (cf. section 6.2.1), give an insight to the debate between generativists and constructivists.

In the final chapter, I will discuss the results from the studies in chapter 5 and 6, and aim to discover which approach is best suited to describe how children acquire morphology. I will also show how research on SLI contributes to the debate on processes governing past tense production.

2. Language Acquisition

2.1 General Theories

The cognitive processes involved in English past tense production stand at the center of an intense debate on the nature of language acquisition. According to Westermann and Ruh (2012), Pinker (1999) refers to English past tense as the "drosophilia[1] of psycholinguistics" because it can serve to answer more general questions on the organization of the language system, and the mind in general.

> Like fruit flies, regular and irregular verbs are small and easy to breed, and they contain, in an easily visible form, the machinery that powers larger phenomena in all their glorious complexity (Pinker 1999: ix).

The debate centers on the necessity and existence of abstract mental rules. How is the cognitive system organized? One view, originated by Chomsky (1957), and further developed by, among others, Pinker and colleagues (1988, 1999), states that abstract rules play a central role in human language processing. The school of theory is known as the generativist approach to language acquisition. It is part of a broader view on the human cognitive system which holds that cognitive mechanisms are symbolic, innate and domain-specific (Pinker 1991).

A second approach to language acquisition, the constructivist approach, challenges the need for abstract rules to explain language processing. Rumelhart and McClelland (1986) showed that a computer simulation of an associative network could acquire hundreds of regular and irregular verbs and generalize them properly to dozens of new verb without the presence a rule algorithm (cf. section 4.1.1). They argue that cognitive processes can be described as graded, probabilistic, interactive, context-sensitive and domain general (McClelland and Patterson 2002). In the two following sections I will give an introduction to child language acquisition by comparing the generativist (chapter 2.1.1) and the constructivist (chapter 2.1.2) approach.

[1] A fruit-fly of the genus so called, much used as an experimental subject in the study of genetics (OED).

2.1.1 Generativist Approach

According to the generativists, the knowledge of grammatical categories, such as verbs and nouns, verb phrases and noun phrases, is an innate ability. They argue that humans have innate knowledge of syntactic and morphological operations. An example of the latter is knowledge of inflectional suffixes, such as the plural *–s* (e.g. cat/cats) on regular nouns and the *–ed* suffix on regular past tense verbs (e.g. dance/danced) in English.

Languages may not appear to be very similar to each other, so how can the generativists claim that all language users have innate, shared knowledge? One key aspect is the distinction between language specific and universal knowledge of grammar. To apply *-ed* to regular verbs or *-s* to plural nouns is language specific knowledge which occurs only in English. However, the abstract knowledge of a rule-based system for morphology and syntax is found in all languages and considered to be innate by the generativists (Ambridge and Lieven 2011: 121/122).

Noam Chomsky's theory of *Universal Grammar* explains the uniformity of language by a biologically endowed innate *Language Faculty.* The *Language Faculty* provides children with genetically transmitted algorithms for developing grammar on the basis of linguistic input (Radford 2004: 11). Thus, children can in principle acquire any language as their native language[2]. If all language uses are born with a *Language Faculty*, some aspects of language should also be shared. These entities are referred to as *Universal Grammar Principles.* As these principles are shared by all languages they determine the very nature of language (Radford 2004: 14).

The Principle and Parameter theory explains how grammatical knowledge could be both universal and language specific. According to this theory, children set parameters based on the input they receive, i.e. according to which language they acquire. One such parameter is the head-direction parameter. A language can be either head first or head final. In the English sentence "(I) hit him", the verb ("hit") precedes the complement ("him"). When the verb precedes the complement, the language is a head-first language. In Korean, the verb is in the final position, "(I) him hit". As the complement precedes the verb in Korean, the language is a head-final language.

[2] Given that the child acquires the language prior to the critical period for acquisition of syntax, age 9-10, they will achieve native competence (Radford 2004: 13)

Table 1 An example showing head parameter in English and Korean

English Head-first parameter	**Subject**	**Verb**	**Object**
	I	hit	him
	She	likes	football
Korean Head-final parameter	**Subject**	**Object**	**Verb**
	I	him	hit
	She	football	likes

Generativists claim that children are born with knowledge of phrase structure, but they have to set the head-direction parameter according to which language they are acquiring. The former is universal knowledge, while the second is language specific.

> Under generativist accounts, children's innate knowledge of language (i.e. the knowledge of language with which they are born) consists of three things:
>
> (1) Knowledge of phrase structure; i.e. syntactic categories and basic rules for combining them into phrases and sentences.
> (2) Principles of language
> (3) Parameter for aspects of syntax that cannot be innate because they vary across languages (e.g. the head-direction parameter) (Ambridge and Lieven 2011: 121)

With this knowledge the child is able to generate (hence the name generativist) sentences she or he has never heard before.

2.1.2 Constructivist Approach

Constructivists argue that children construct language solely based on the input they receive. The input is organized based on generalizations and analogy. If the child hears and produces some regular past tense verbs, they will form other past tense verbs by analogy. For example, if they produce "danced" and "played", they will, by analogy transfer this information to other verbs and produce more past tense verbs with the regular suffix. They will also come across

the irregular patterns such as the one forming "knew" from "know" and not "knowed". By analogy, the child produces irregulars "throw/threw" and "grow/grew" from the same pattern.

According to constructivists, such as Bybee and Slobin (1982) generalizations of the regular suffix are not in the form of rules, but according to schemas. "A schema is a statement that describes the phonological properties of a morphological class (in this case, past tense). It does not relate a base form to a derived one, as a rule does, but describes only one class of forms" (Bybee and Slobin 1982: 267).

Constructivists argue that children acquire syntax based on the communicative function of a word or phrase. They start of by learning individual sentences such as "I am eating it" or "I am kicking it". As the child will hear and produce different action sentences, they will acquire a pattern and create the schema "I am ACTIONing it". When they have acquired this pattern, they can insert any action-word and produce action sentences (Ambridge and Lieven 2011: 126). According to the constructivist approach, sentences are formed according to patterns such as 'NOUN1 VERB NOUN2', where NOUN1 acts upon NOUN2, whereas generativists claim the information regarding who or what is being affected, lies in the verb. This type of information is encoded in the lexicon in the form of semantic and syntactic roles. The verb "eat" requires two semantic roles, an agent (the entity that performs the event denoted by the verb), and a patient or theme (the entity that is acted upon in the event denoted by the verb). The syntactic roles that 'eat' requires are a subject noun phrase (to express the agent) and an object noun phrase (to express the patient or theme) (Ambridge and Lieven 2011: 118/124).

2.1.3 Single or Dual-Route Model?

One of the generativist arguments is that the syntactic system is too complex and too abstract to be acquired on the basis of input alone. This argument is often referred to as *poverty of stimulus* (Valian 2009: 20). Generativists argue that knowledge of a rule, such as VERBed in forming of regular past tense or NOUNs when forming regular plurals, can explain how children produce thousands of verbs and nouns without storing them as individual entities. They claim that formation of regulars and irregulars are two different mechanisms.

> Irregular past-tense forms (e.g. *threw*) are stored in the lexicon (the 'mental dictionary'). However forms are stored not as a simple list, but clustered into **phonological neighbourhoods** (also called **families** or groups of **friends**), such as *throw/threw, blow/blew, know knew* or *sleep/slept, weep/wept, creep/crept*. (…)

> Regular past tense forms are not stored in the lexicon. The stem (e.g. *walk*) is stored, and the past tense formed by the application of a **default rule** 'add –ed'. This default rule steps in whenever a stored irregular past-tense form is unavailable, either because the verb does not have an irregular past-tense form (i.e. is regular), or the speaker is unable to remember the irregular past-tense form. Importantly, the default rule is 'capable of operating on any verb, regardless of its sound' (Prasada and Pinker, 1993: 2). However, if an irregular form is retrieved (or generated by analogy with phonologically similar forms), this blocks application of the default rule (Ambridge and Lieven 2011: 170).

Arguing that regulars and irregulars are produced in two qualitatively distinct mechanisms, the generativist approach to inflectional morphology has been labeled the *Dual-Route Model*.

The alternative account, by the constructivists, has been labeled the *Single-Route Model*. According to the constructivists, "the emergence of rule like behavior is not determined by the acquisition of a symbolic rule, but by the gradual and incremental exposure to regular verb types" (Serratrice et al. 2003: 326). How fast a child will learn different types of verbs is not based on whether they are regular or not, but on how frequent the forms are in everyday conversation. The regular pattern has a high type frequency, i.e. a high number of the verbs and nouns that children are exposed to, inflect regularly. According to the constructivists this leads children to overgeneralize the regular pattern. Children produce overgeneralizations that are not found in adult speech, such as "runned", "goed" and "keeped". As the irregular pattern has a relatively low frequency there are rarely overgeneralizations of this pattern (Serratrice et al. 2003: 327).

2.2 Regular Language Acquisition

Noam Chomsky (1957) describes children's language development as uniform across languages. The rapidity and uniformity of child language acquisition has been considered an argument in support of an innate rule *Language Faculty* (cf. section 2.1.1). However, both generativists and constructivist, agree that children acquire language in a similar manner. In this section I will describe some of the characteristics of child language acquisition.

First, the early acquisition of semantic relations is quite similar across languages (Gleason and Ratner 2009: 153). During the early stages of language acquisition, children often speak about objects, actions and their relation to the object. It has been observed that the first two-word

utterances children produce usually have the same semantic relations. As reported by Gleason and Ratner (2009: 153), Brown (1973) listed the following as the most prevalent semantic relations in early language acquisition:

Table 2 The most prevalent semantic relations in early language acquisition

Semantic Relation	Examples
Agent + action	Mommy come, daddy sit
Action + object	Drive car, eat grape
Agent + object	Mommy sock, baby book
Action + location	Go park, sit chair
Entity + location	Cup table, toy floor
Possessor + possession	My teddy, mommy dress
Entity + attribute	Box shiny, crayon big
Demonstatrtive + attribute	Dat money, dis telephone

(Gleason and Ratner 2009: 153)

Second, as has been shown by Brown (1973) children often acquire morphology in a similar manner. Crucially, it is not children of a similar age who acquire morphology in a similar manner, but children who are at the same stage of language development. Language development is often measured in the number of morphemes a child produces per utterance. This is known as MLU (Mean Length of Utterance). Brown (1973) introduced this measure to develop an index which describes morphosyntactic growth. The index is based on longitudinal studies of three American children. Table 3 presents Brown's (1973) five stages of syntactic growth.

In their two word stage, children often produce lexical items that are labeled content words. These are primarily nouns, but also verbs and adjectives. The function words, such as prepositions, conjunctions, pronouns, auxiliaries are often missing at this stage. Grammatical features such as inflectional suffixes or other forms of tense marking are rarely present at this early stage (Gleason and Ratner 2009: 152).

Table 3 Five stages of syntactic growth

Stage	Morphemes	MLU
1	Telegraphic Speech (no morphological marking)	1.50
2	Present progressive, plural and the prepositions *in* and *on*	2.25
3 & 4	Past irregular, third person irregular, uncontractible copula and articles	2.75-3.50
5	Third person and past regular, contractible and uncontractible auxiliaries and copula	4.0

Based on Brown (1973) quoted from (Behrens 2009: 206)

2.2.1 Optional Infinitive Phase

When children start to produce verbal inflectional morphology, they only mark tense and agreement in some contexts. This period is known as the *optional infinitive phase* (Rice et al. 1998). During this period children alternate between infinitive forms and finite forms and may produce sentences, such as "I *bump* my head" or "The doll *fall* down". Rice and Wexler (1996) wondered how children acquire morphological knowledge such as tense properties (that *-ed* specifies past tense and *–s* represents present tense in 3rd person singular). Why do children produce sentences such as "Yesterday I **bump* my head", but rarely "Yesterday I **bumps* my head"? None of these sentences are present in adult speech production. Rice and Wexler's study showed that

> When a *past* context was used, children either used the correct past verbal form *she painted pictures* or an OI [Optional Infinitive] *she paint pictures.* Out of large numbers of elicited productions children almost never used a present form *s* in a past context or a past form *ed* in a present context. There can be no question that these children knew that *ed* is +past and that *s* is -past. (Wexler 1998: 42, [MEM])

This shows that during the *optional infinitive phase,* children have knowledge of subject verb agreement, though they consider finite forms optional in finite contexts. Thus, the unmarked utterance "Yesterday I **bump* my head" may occur, while the ungrammatical utterance "I **bumps* my head", rarely occurs.

Wexler (1998) proposed the *Agreement/Tense Omission Model* to explain why children use infinitive verbs in contexts where adults would use finite forms. In the early stages of language acquisition a child can check a verb for either agreement or tense, but not both. Wexler (1998: 63) labels this the *Unique Checking Constraint*. The constraint fades away as the child is exposed to input marked with both tense and agreement. This is referred to as "UG-constrained maturation".

2.2.2 Individual Differences

Brown (1973) claims that children acquire language in a similar manner, though there are individual differences both in relation to rate and style of acquisition. Bates et al. (1995) argue that individual differences in language acquisition have been largely ignored by researchers and left to applied practitioners (such as speech therapists, speech pathologists and special educators). According to Bates et al. (1995) research on word comprehension, word production and first word combinations shows that "there are enormous individual differences in onset time and rate of growth in each of these components" (Bates et al. 1995: 97). A study with 1803 participants shows how early vocabulary production is highly variable:

> [A]fter 13 months there is a dramatic increase in variability, due primarily to rapid growth in children at the high end of distribution. At 16 months, for example, children in the top tenth percentile have reported productive vocabularies of at least 154 words, while children in the lowest tenth percentile are still producing no words at all. This highly skewed distribution continues to characterize variation in expressive vocabularies throughout the 16-30-month range, until ceiling effects are operative. For example, at the two-year point (24 months), the mean for reported expressive vocabulary on this measure is 312 words, but the 1.28 standard deviation range goes from a low of 89 to a high of 534. (Bates et al. 1995: 104/105)

Language acquisition might occur in a similar manner, as Brown argues, but there is variation with respect to the age at which the onset of grammar and vocabulary occurs.

All children, showing typical language development, go through the same phases of early language acquisition. First, they go through a phase of *telegraphic speech*, where the majority of utterances regard objects, actions and their relations. When children start to produce verbal inflectional morphology, they go through an *optional infinitive phase (OIP)*, only marking tense and agreement in some contexts. Following the OIP, most children will acquire and

produce inflectional morphology according to Brown's five stages of syntactic growth presented in Table 3. However, not all children acquire language according to the stages described by Brown (1973). Children with *Specific Language Disorder* (SLI) have significant limitation in language ability without any apparent explanation. In the following chapter I will describe the language disorder SLI, and aim to discover how SLI children's language development is deviant compared to children with regular language acquisition.

3. Specific Language Impairment

According to Tomblin et al. (1997) about 7% of English speaking kindergarten children (5-6 years old) show a significant limitation in language ability. This minority of children make much slower progress in language acquisition even though all the prerequisites for language development, such as adequate hearing and intelligence, normal physical development and supportive home environment, are in place (Bishop et al. 2006). This kind of limitation in language ability is referred to as *Specific Language Impairment* (SLI).

3.1 Causes of SLI

The causes of SLI are not known, but researchers are aiming to discover whether the disorder is caused by the language environment, perceptual limitations or the genetic make-up of the child. Bishop (1997) has considered these three factors and argues that SLI is most likely not caused by the language environment.

> Any review of the effects of language stimulation on language development comes to the rather surprising conclusion that grammatical development is relatively insensitive to the quality and quantity of language input from parents and other caregivers, although semantic development is easier to document. If we exclude cases of extreme neglect (see Skuse, 1988), there is no dimension of the child's communicative environment that seems a plausible candidate for causing language problems severe and specific enough as a case of SLI. (Bishop 1997: 44)

Other causes of language impairment are physiological features that might cause perceptual or production limitations, such as brain lesions, ear infections, loss of hearing or oral or sensory deficits. However, these factors are not present in children with SLI.

Bishop (1997) argues that SLI is hereditary. She has conducted twin studies which imply that genes play an important role in determining whether a child develops language impairment or not. I will come back to her research in section 6.1.

3.2 Diagnostic Criteria of SLI

SLI is defined as a pure linguistic impairment as other causes of language impairment have to be excluded to fulfill the criteria for the disorder. Bishop (1997) reproduces the list of criteria presented by Stark and Tallal (1981):

- Normal hearing on pure tone screening
- No known history of recurrent otitis media [middle ear infection, MEM]
- No emotional or behavioural problems sufficiently severe to merit intervention
- Performance IQ of 85 or above
- Normal neurological status (i.e. no frank neurological signs, no history of head trauma or epilepsy)
- No peripheral oral motor or sensory deficits
- Articulation age (assessed on Templin-Darley's 1960 Test) no more than six months below expressive language age
- In children aged seven years or above reading age no more than six months below language age
- Language age (mean of receptive language age and expressive language age) at least 12 months lower than chronological age or performance mental age, whichever was lower
- Receptive language age at least six months lower than chronological age or performance mental age, whichever was the lower
- Expressive language age at least 12 months lower than chronological age or performance mental age, whichever was the lower

(Bishop 1997: 26)

In the list of criteria, age is referred to as both chronological and performance mental age. As normal language acquisition is not homogeneous, children will acquire language at different rates. However, if their language development is delayed by as much as 12 months, there is reason to suspect language impairment.

It is important to compare the child's performance on both linguistic and non-linguistic tasks. One way of establishing the child's nonverbal IQ is to provide her with nonverbal logical tests. If the child has performance IQ of 85 or higher on nonverbal tasks, reduced cognitive ability in other areas than language can be excluded.

Tomblin (2009) reports of research (Bartak et.al. 1975, 1977 and Bishop & Norbury) testing the hypothesis that SLI and autism may be examples of a spectrum disorder involving communication. Tomblin (2009) argues that children with SLI and autism are similar when compared on production of morphology, syntax and semantics, but contrast with regard to pragmatics and social cognition. As there appears to be an overlap between the disorders, some researchers argue that SLI is a mild variant of autism. However, as not all children with autism have impaired language, it has also been argued that the two are co-morbid conditions (Tomblin 2009: 420/421).

3.3 Deviant or Delayed Acquisition?

This section focuses on the question of whether children with SLI acquire language in a significantly different manner than their typically developing (henceforth abbreviated to TD) peers, or whether language acquisition is just delayed. Two hypotheses have been put forward to describe language acquisition in children with SLI, the *Deviant Hypothesis* and the *Delayed Hypothesis*.

Supporters of the *Delay Hypothesis* argue that features which are present in SLI children can be found in younger children with regular language development. One example is the *Optional Infinitive Phase* (cf. section 2.2.1). Rice et al. (1995) argue that this phase, when the child is not marking tense in all obligatory contexts, is extended in children with SLI. This is known as the *Extended Optional Infinitive Phase*.

Other supporters of the *Delay Hypothesis* argue that children with SLI do not produce language which is significantly deviant from that produced by regularly developing children. There are examples of SLI children using nouns as verbs such as "*brooming*" and "*barefeeting*", or using the object pronoun in contexts calling for a subject pronoun, as in "*Me want the dolly*" and "*Him pushing car*" (Leonard 1998: 35/44). These are forms which are not part of adult speech, but all children produce forms which are considered to be errors by adult speakers. It is not the errors themselves that cause a problem for children with SLI, but that they continue to produce them when other children stop.

Critics of the *Delay Hypothesis* argue that children with SLI are not just late talkers. They have a higher percentage of errors than TD children and may not reach full maturity of language as adults. Erroneous use of inflectional morphology is common for SLI children. Research has shown that children with SLI have deficient working memory (cf. section 5.2.4). Due to limited processing capacity they have a reduced ability to mark tense and agreement. As other children do not show a similar deficit while using working memory this is deviant compared to regular acquisition, thus in support of the *Deviance Hypothesis*. The (Leonard 2009: 440).

3.4 Language Characteristics of children with SLI

3.4.1 Lexicon

Children with SLI are often late talkers. A number of studies which go back to the 1940s and 1950s show that some children fail to produce words until they were 5 years old. More recent studies have confirmed these findings. Trauner et al. (1995) collected information on 71 children with SLI and 82 typically developing age-matched control children. According to information given by the parents, SLI children had an average age of first words of almost 23 months, while regularly developing children start to produce words at approximately 11 months (Leonard 1998: 43).

Studies on lexical acquisition show that preschool children with SLI use a similar amount of object and action words as children with regular language development (the control group). However, the SLI children had a more limited variety of verbs than children in the control groups. Studies of older children with SLI show that they "learned object names almost as well as did age controls, but their learning of action names fell well below that of their same-age peers." (Leonard 1998: 46) Older children with SLI often have a "word-finding" problem. This can be observed as pauses, naming errors, frequent use of nonspecific words such as "it" or "stuff" and the use of substitutions which are similar in sound or meaning (Leonard 1998: 46).

3.4.2 Syntax

According to Leonard (1998: 46) children with SLI often have greater difficulty acquiring verbs than nouns. Gleitman and Gleitman (1992) argue that the developmental priority of nouns is related to the fact that nouns typically label objects, while verbs label relationships among object concepts.

> For example, *hit* expresses a relationship between two entities (the *arguments* of the verb), the hitter and the one hit. To understand *hit*, then, one must understand the type of relationship (the short, sharp contact) and the argument structure. (Gleitman and Gleitman 1992: 31)

Thus, acquiring and producing verbs requires more complex grammatical knowledge than producing nouns. The child has to acquire argument structure. Argument structure is the specification of number and types of arguments required to produce a verb in a well-formed sentence. Arguments can be identified in two ways, semantic roles (i.e. subject/object) and thematic roles (i.e. agent/patient) (Allen 2009: 217).

One way of establishing whether a child has acquired a verb, is to test whether or not he or she omits obligatory arguments. One of the earlier studies, namely Lee (1976), compared preschoolers with SLI and younger TD children. Lee saw that both groups were similar in the use of argument structures, but SLI children were more likely to omit obligatory arguments. They produced sentences such as "*Doggie get*" and "*He put his finger*". Later studies by Rice and Bode (1993) showed that object omission is more common that subject omission in children with SLI (Leonard 1998: 51).

Several studies have been conducted to compare the syntactic development in TD children and SLI children. One recurring result is that when both groups are of the same chronological age, the SLI children produce more errors. However, if the two groups have similar MLU, the SLI children do not produce a larger number of errors than the MLU matched control group. Morehead and Ingram (1970, 1973) compared SLI and TD children with similar MLU. They discovered that even though their sentence production appeared to be quite similar, there were important differences between the two groups. "The children with SLI did not use major syntactic categories (e.g. noun, verb, embedded sentence) in as many different contexts, on average, as the MLU controls". (Leonard 1998: 57) This shows that there is more to language production than counting errors. If measured by the number of mistakes, the SLI children scored just as well as MLU controls, but their sentence construction was not as complex.

3.4.3 Phonology

One important part of speech production is the production of sounds. The study of speech sounds is known as phonology. Studies on phonology may shed light on whether the difficulty for children with SLI lies in the production of sounds, or the cognitive processes

conducted prior to speech production. According to Leonard (1998), children with SLI have the same pattern of acquiring speech segments as other children. Studies of SLI children and their MLU matched controls have showed that SLI children have fewer problems with pronunciation than their peers. According to Ingram (1981) the group of TD children had a higher production error rate with voicing contrasts, such as "*coal/goal*", than the SLI children (Leonard 1998: 73). This may not be a very surprising result as the SLI children were older and had a more developed system for speech production than the younger TD children. However, it shows that the main problem for SLI children is not likely to be in the production of speech sounds.

4. Past Tense Production

In section 2.1, I briefly compared constructivist and generativist approaches to child language acquisition. One of the main areas of research, well suited to explore the nature of language acquisition and processing, is production of past tense. The constructivist approach has been labeled the *Single-Route Model* because its proponents argue that all forms (both regular and irregular) are stored in the memory system and retrieved in the same manner. Conversely, the generativist approach has been labeled the *Dual-Route Model* as its advocates maintain that the formation of irregular and regular past tense is subject to two different mechanisms: irregulars are stored in the lexicon and retrieved as one cluster of information, while regulars are formed by applying the default rule (–ed) to the stored stem (Ambridge and Lieven 2011: 170).

4.1 Overgeneralization

My aim is to discover whether differences in past tense acquisition in two groups of children, SLI children and TD children, supports the generativist or the constructivist approach to language acquisition. How can one measure morphological processing? Is it possible to test whether past tense production is best described using a *Single* or *Dual-Route Model*?

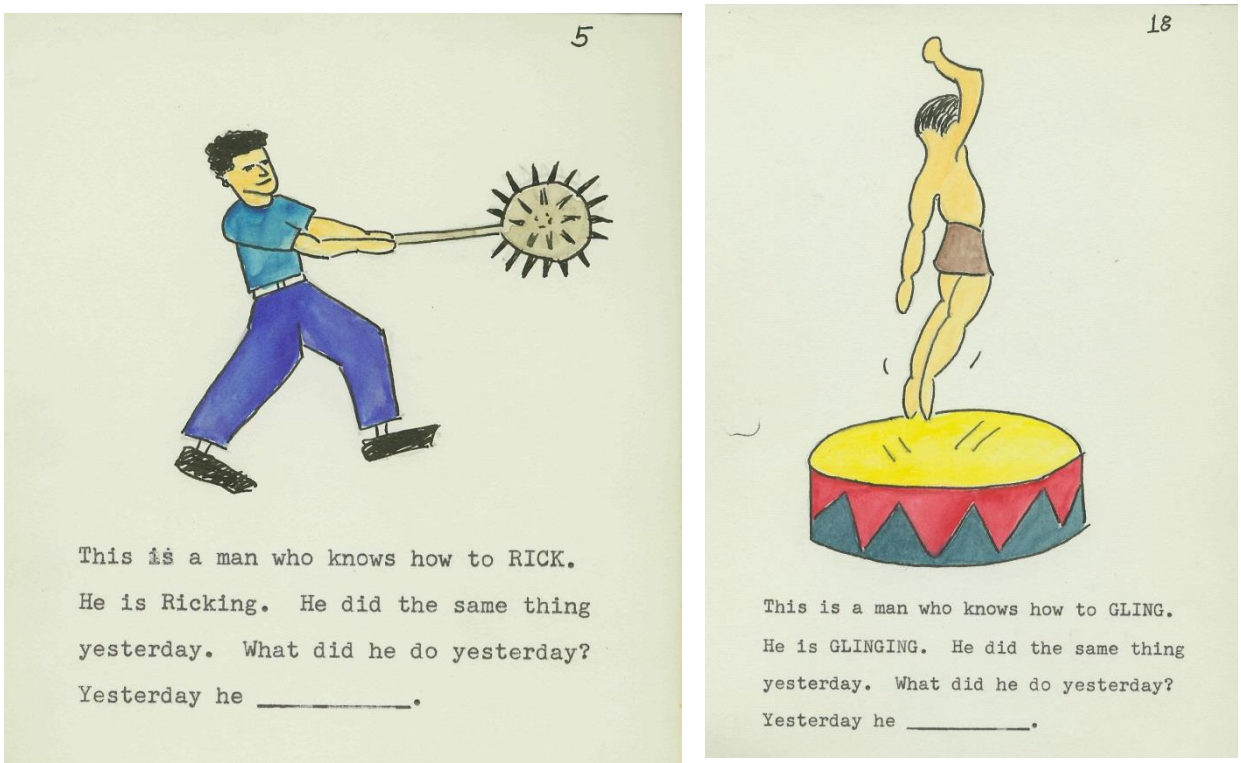
One way of testing the two approaches is to consider overgeneralization errors[3]. Children produce past tense forms rarely heard in adult language. To produce the regular suffix /ed/ on an irregular verb, such as *keeped* (overgeneralization of *kept*), is known as an

[3] It is somewhat misleading to consider overgeneralization errors actual errors, or something the child should not produce. Quite contrary, all children produce overgeneralizations, they are a natural part of language development, and will only be considered errors when compared to adult language production.

overgeneralization error. Children produce both regularization errors (the use of the regular suffix on irregular past tense verbs, such as “goed” for “went”) and irregularization errors (overgeneralization of one of the irregular patterns, such as “sit” for “sat”) (Marchman et al. 1997: 207).

Berko (1958) created a method for collecting data on overgeneralization errors. She designed a test, in which children are provided with drawings of someone or something preforming an action together with a verbal description of the depicted scene. The verbal description contains a novel verb which describes the depicted action in the present progressive. To find out how children produce past tense verbs, they are asked to answer how this action was preformed yesterday. Images from the original test by Berko (1958) is presented in Figure 1.

Figure 1 Images from the Wug test



(Berko 1958: 150-177)

Berko tested production of plural and possessive inflection on nouns and progressive, third-person present tense and past tense production of novel verbs. The test has been labeled the “*Wug* test” after the initial novel noun used in the test, a birdlike creature called “a *Wug*”.

The aim of the Berko's test is to collect data on how children produce novel inflected verbs. The verbs had to be novel to assure that the children were constructing new past tense verbs, not already known forms from memory. When the children produced "Yesterday the man rick**ed**", it is evident that there exists some kind of internalized knowledge of a rule-based system. The child has never heard this morpheme before so it cannot have been learned by imitation (Gleason and Ratner 2009: 162).

However, whether the child produce "rick**ed**" by analogy to other regular verbs, or by adding the past tense rule "-ed" to the stem "rick", cannot be tested by the "*Wug*-test". Constructivists would argue that children produce "ricked" by analogy to similar sounding regular verbs such as "pick/picked" or "lick/licked" (cf. section 2.1.2) and not on the basis of an innate rule.

In the following section I will discuss studies on overgeneralization errors. Generativists and constructivists have differing assumptions as to what occurs at the onset of overgeneralization. In section 4.1.1 I will present Rumelhart and McClelland's (1986) model of past tense production. The model has been considered an argument for the constructivist approach to language acquisition. Section 4.1.2 refers to criticism of Rumelhart and McClelland's (1986) model by Pinker and Prince (1988). Section 4.1.3 presents studies on the rate of overgeneralization errors by generativists, Marcus et al. (1992) and criticism by Maratsos (2000).

4.1.1 Rumelhart and McClelland (1986)

One of the central works on past tense production is *Parallel Distributed Processing (PDP): Explorations in the Microstructure of Cognition* by Rumelhart and McClelland (1986). They programmed a computer simulation of the acquisition process and provided the program with hundreds of regular and irregular verbs. The model consists of two parts "(a) a simple *pattern associator* network (…) which learn the relationship between the base form and the past-tense form, and (b) a decoding network that converts a featural representation of the past-tense form into phonological representation" (McClelland and Rumelhart 1986: 222). The results showed that the program managed to simulate past tense production with a striking similarity to child language production. It generalized dozens of verbs it had not been trained on, similar to child language production on novel verbs in the "*Wug*-test". Rumelhart & McClelland (1986: 221) describe overregularization in three stages. In stage 1 the simulation program will produce

few verbs, but the verbs will be correct (not overgeneralization errors), in stage 2 the simulator starts to produce more verbs, and some will be overgeneralizations (correct forms are never completely absent), in stage 3 the program regains the use of correct irregular and regular forms. This PDP-simulation produced overgeneralizations in a pattern similar to the stages described in child language. Rumelhart and McClelland's simulation shows that it is not necessary to encode a rule system dividing regulars from irregulars to be able to reproduce children's past tense production. Thus, it has been considered an argument in support of the constructivist, *Single-Route*, approach to past tense acquistion.

Rumelhart and McClelland (1986) "taught" the model how to produce regulars and irregulars in the same manner:

> The model is trained by providing it with pairs of patterns, consisting of the base pattern and the target, or correct, output. Thus, in accordance with common assumptions about the nature of the learning situation that faces the young child, the model receives only correct input from the outside world. However, it compares what it generates internally to the target output, and when it gets the wrong answer for a particular output unit, it adjusts the strength of the connection between the input and output units so to reduce the probability that it will make the same mistake the next time the same input pattern is presented (McClelland and Rumelhart 1986: 239/240).

The simulator is provided with phonological representations of stems and inflected forms. For the program to be able to consider the stems as sequences of sound and not individual phonemes, each word was converted into *Wickelphones*. A *Wickelphone* is a representation of a phone "as a triple, consisting of the phone itself, its predecessor and its successor" (McClelland and Rumelhart 1986: 233). The predecessor of the initial phoneme and successor of the final phoneme is marked by #. Examples are presented in Table 4.

Table 4 Verbs presented phonologically and by Wickelphones

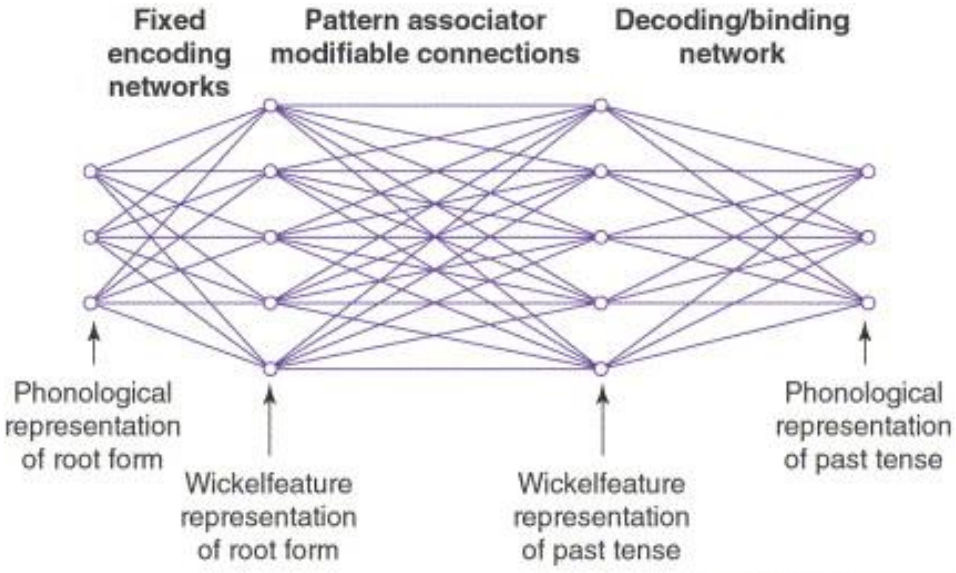
Verb	Phonological representation	Wickelphones
Hit	/hɪt/	#h$_{i}$ h$_{t}$ i$_{t}$ t#
Sing	/sɪŋ/	#s$_{i}$ s$_{ŋ}$ i$_{ŋ}$ ŋ#

The benefit[4] of using *Wickelphones* is that they provide sufficient basis to form the different forms of the regular and irregular past-tense patterns. For example, the input of stem final "$_{i}ŋ_{\#}$", is sufficient to produce the past tense suffix "$aŋ_{\#}$" based on the irregular "ing->ang" pattern (found in "ring/rang", "sing/sang").

Figure 2 shows the basic structure of Rumelhart and McClelland's model. The model consists of two parts, *a pattern associator network* and a *decoding network*. The *pattern associator* learns the relationship between the present and past tense form, while the *decoding network* converts the past tense form into a phonological representation.

Through this model, Rumelhart and McClelland showed that children's past tense production can be simulated in the absence of a rule (or rule system). An associative network, based on input of stems and inflected forms, was sufficient to recreate verb conjugation and generalization similar to child language production.

Figure 2 The basic structure of McClelland and Rumelhart's Parallel Distributed Processing Model



(McClelland and Rumelhart 1986: 222)

[4] The downside to Wickelphones is that they are too specific, thus there will be too many of them. McClelland & Rumelhart argues for a more general representation of patterns of Whickelphones, known as Wickelfeatures. For further discussion on Wickelfeatures see McClelland & Rumelhart (1986: 234/239)

4.1.2 Pinker and Prince

Rumelhart and McClelland's work has been idiomatic for the constructivist camp. However, the generativist school has not left their PDP-model unchallenged. Pinker and Prince (1988) listed eight objections in their analyses of Rumelhart and McClellands's computer simulation program of child language acquisition.

> (1) it cannot represent certain words, (2) it cannot learn many rules, (3) it can learn rules found in no human language, (4) it cannot explain morphological and phonological regularities, (5) it cannot explain the differences between irregular and regular forms, (6) it fails at its assigned task of mastering the past tense of English, (7) it gives an incorrect explanation for two developmental phenomena: stages of overregularization of irregular forms such as *bringed*, and the appearance of doubly-marked forms such as *ated*, and (8) it gives accounts of two others (infrequent overregularization of verbs ending in t/d, and the order of acquisition of different irregular subclasses) that are indistinguishable from those of rule-based theories. (Pinker and Prince 1988: 73/74)

I will give a few examples of the shortcomings Pinker and Prince are referring to in their list.

Their first claim is that the model cannot represent certain words. Rummelhart and McClelland model's produced past tense output based on present tense input. The input was given in the format of Wickelphones where each phone is represented with its own information, as well as with the information of its predecessor and its successor. Pinker and Prince (1988: 13) argue that Wickelphones are too coarse to support generalization because they refer to *phonemes*, rather than *phonetic features*. *Phonetic features* are properties describing a *phoneme*. For example consonants have *phonetic features* describing place and manner of articulation and whether it is voiced or unvoiced. For example, the phoneme /d/ has the following phonetic features; alveolar (place of articulation), stop (manner of articulation), voiced (voicing). The last feature (+/-) voicing is, according to Pinker and Prince, crucial to determine the inflectional pattern of certain verbs. They give the example of the verbs "pass" /pas/ and "walk" /wɔk/ in British English. The final phoneme in both verbs is unvoiced (/s/ and /k/). The model would be able to produce the correct irregular suffix /-t/ to both /past/ and /wɔkt/ because /s/ and /k/ are familiar phonemes in English language. To prove their point, Pinker and Prince (1988: 13) provide us with an example. If the name of the famous composer "Bach" was used as a verb, "to Bach", the final phoneme /x/ would be unfamiliar to a child

acquiring English simply because the unvoiced velar fricative /x/ is not found in final position in any English verb. However, a child stumbling across this novel verb would have no problem producing a past tense form of the verb. In contrast, the PDP-simulator would not be able to recognize the irregular pattern "/bax/ -> /baxt/" used to form "/pas/ -> /past/" and "/wɔk/ -> /wɔkt/", as phonetic features, such as +/- voicing, has not been encoded into Rumelhart and McClelland's model. This is a weakness in the encoding of the simulator program according Pinker and Prince.

This shows one area where the simulator is not similar to child language acquisition. Another area where the simulator would struggle is inflection of homophones (cf. section 5.1.2 for a detailed discussion). Homophones are different lexical items with phonologically identical stems. An example of a pair of homophones from Pinker and Prince (1988: 25) are "lie -> lied" and "lie -> lay". Rumelhart and McClelland's model would not be able to distinguish whether the input "lie" should be interpreted as; "to be in recumbent position (OED)[1] or "to speak falsely (OED)[2]", and thus cannot be compared to a child acquiring language, who will be able to acquire the two different forms of the homophone "lie".

Pinker and Prince (1988) argue that there are several differences between Rumelhart and McClellenad's simulation of past tense acquisition, and actual child language acquisition. However, in my opinion, the only solution to their criticism is not that there exists an innate knowledge of a rule. The inflection of foreign words (or sounds) such as "to Bach/Bached", can be explained by formation of regulars by analogy to the regular pattern. The same argument can be made for homophones. They may also be produced by analogy to an irregular pattern (lie/lay) if the regular pattern has been blocked by a different lexical item (lie/lied).

4.1.3 Rate of Overgeneralization Errors

4.1.3.1 Marcus et al. (1992)

In the introduction to this chapter I argued that studies on the rate of overgeneralization might reveal whether the *Single* or *Dual-Route Model* is the best approach to describe child language acquisition of past tense. The two models rest on different assumptions as to how children overgeneralize. Supporters of the *Dual-Route Model* claim that the error rate of overgeneralization errors will be very low once a particular irregular form has been learned. If one irregular form has been acquired (e.g. *came)*, the irregular form will block the default rule

(add *-ed*), and regularization errors (e.g. *comed*) should cease immediately. This is known as the *Blocking Principle* (Marcus et al. 1992: 8/9).

According to the *Single-Route Model* overgeneralization errors will persist for a period of time, even though the irregular form has been acquired. This is because the regular form will remain as a competing pattern (Ramscar and Yarlett 2007: 931).

None of the approaches argue for a specific quantity known as *children's overgeneralization rate*, but the generativists argue that the rate will be low. Marcus et al. (1992), a group of generativists, argue that overgeneralizations occur when the child's memory retrieval fails. Thus, the overgeneralization rate will never be 0% as a child's memory is not perfect.

> If we assume that children's memory for words, although imperfect, is quite good (the child is, after all, successfully using thousands of words and acquiring them at a rate of approximately one per waking hour; Miller, 1977), then overreguarlization should be the exception, not the rule, representing the occasional breakdown of a system that is built to suppress the error. The overreguarlization rate, therefore, while not being 0%, should be as close to 0% as the child's rate of successful memory retrieval permits. (Marcus et al. 1992: 18)

In their study of 25 children Marcus et al. (1992: 35) found the median overregularization rate to be 2,5%, while the average rate was 4%. They collected data from different studies in the CHILDES[5] database. The youngest child was 1.3 years at the beginning of the data collection, while the oldest was 5.2 years on the last session. All of the children were recorded over periods of more than 12 months (some occasionally, while others weekly or monthly). The medium and average rates were calculated from the entire sampling period. However, when looking at the monthly overregularization rates, some outliers were found. Four of the children from the CHILDES database produced the following rate of overregularization errors. Abe showed an overregularization rate of 47.6%, Eve 23.1%, Sarah 15.8% and Adam's highest rate was 6.8% (Marcus et al. 1992: 40). Despite the fact that the overgeneralization rate almost reached 50% in a speech sample, Marcus et al. (1992) argue that the study supports the *Dual-Route Model*.

[5] CHILDES (Child Language Data Exchange System) is a Web-based database containing language data contributed from over one hundred research projects around the world (Gleason and Ratner 2009)

> Minimally, an observed overregularization rate, that is systematically less than 50% and not attributable to any factor confounded with irregular forms would serve as evidence that the child's language system is biased against overregularization in favor of an irregular form when it is available. Blocking effects exactly that bias, and the lower the rate turns out to be (assuming that it is less than 50%), the less need we would have for any explanation other than blocking and retrieval failure (Marcus et al. 1992: 18).

In other words, if the overregularization rate is systematically lower than 50%, the data supports Marcus et al.'s (1992) *Blocking and Retrieval Failure Hypothesis*.

4.1.3.2 Maratsos

Maratsos (2000) is critical of Marcus et al's (1992) interpretation of the overregularization rates. In this section I will present three critical arguments from Maratsos (2000)

First, Maratsos (2000) considers the same data as Marcus et al. (1992) and claim that sampling problems and how the data is interpreted may conceal high overregularization periods. Marcus et al (1992:29) decided to exclude individual irregular verbs that were sampled 10 times or less to avoid unreliable estimates. Maratsos (2000) considers the overregularizations of one of the children (Abe) from Marcus et al's data (1992). Out of 65 verbs produced by Abe, 40 were produced less than 10 times. He argues that it is an error to exclude such as a high number of verbs because they play an important part in giving an accurate picture of the rate of overregularization. Maratsos (2000) gives an example by comparing Abe's overregularization rate on the most frequent verb *say* with the error rate on Abe's 40 less frequent verbs. *Say* was sampled 185 times, with a very low rate of overregularization, only 1% overall. However, the 40 less frequent verbs had a very high overregularization rate, notably 58% (Maratsos 2000: 189). This shows that the interpretation of the data would be different if these 40 verbs had been included in the analysis of Abe's data. An overregularization rate higher than 50% is an argument against the *Blocking and Retrieval Failure Hypothesis* (cf. section 4.1.3.1) by Marcus et al (1992).

Second, Maratsos (2000) is critical to the computation method of overregularization rates. Marcus et al. (1992) method for calculation is shown in Figure 3.

Figure 3 Calculation of overregularization rate in Marcus et al. (1992)

$$\frac{\text{(No. of overregularization tokens)}}{\text{[(No. of overregularization tokens) + (No. of correct irregular past tokens)]}}$$

(Marcus et al. 1992: 29)

Maratsos (2000) argues that when all of the irregular tokens are pooled together[6], the highly frequent verbs, that have a low overregularization rate, will statistically dominate the overall rate. For instance, the highly frequent production of *saw* (285 times) in Abe's speech data will contribute more responses than 28 verbs sampled 10 times each. With this approach the overregularization rate of one verb has the same (or even greater) influence on the overall rate as 28 less frequent verbs combined. As the less frequent verbs often cause a higher rate of overregularization, the overall rate would be higher if the influence of each token was weighed according to type frequency, not token frequency. This would result in a higher rate of overregularization errors, which again is an argument against the *Blocking and Retrieval Failure Hypothesis* and the *Dual-Route Model*.

Third, Maratsos (2000:184) argues that empirical evidence from longitudinal studies (by Cazden 1960 & Kuczaj 1977) show that children produce both the irregular and regular past tense forms of the same irregular verb. They may alternate between forms for several months. He considers this an argument against the *Blocking and Retrieval Failure Hypothesis* as blocking should banish overregularization, once the irregular past tense form has been acquired.

4.1.4 Zero-marking errors

Another area where the two models yield different results is zero-marking errors. A zero-marking error is to produce infinite verbs in finite contexts. Such errors are common in child language during the *Optional Infinitive Phase* (cf. section 2.2.1) An example of a zero-marking error is to produce the verb *come* in a sentence such as "Yesterday he **come* to us".

[6] Token frequency refers to the number of times one kind of irregular verb occurs. For example *Saw* has a token frequency of 285 in Abe's speech data. The type of verb "to see" is represented by 285 past tense tokens in Abe's sample. More on the distinction type/token in section 5.2.2.2

According to the *Dual Route-Model* zero-marking errors should disappear as soon as the child starts to produce regularization errors. This is explained by the *Blocking and Retrieval Failure Hypothesis* (cf. section 4.1.3.1). Regularization errors are evidence that the child has acquired the default rule. The child will use either an irregular form if it has been acquired, or add the default rule if no irregular form is "blocking" the default rule. According to the *Single-Route Model* there should not be a sudden decline, but rather a gradual change as the child is building a VERB+ed construction. However, different researchers have interpreted the same data to be both sudden and gradual. It appears as though the same results can be claimed to support both models.

> Marcus *et al.* (1992: 103) state that "Adam's first over-regularization error occurred during a 3-month period in which regular marking increased from a 0 to 100%", whilst McClelland and Patterson (2002), talking about the same data, state that "Adam's first over-regularization occurred during a six-month period in which the probability of using the regular gradually rose from 24-44%" (these statements are both true, because the rate of 100% represents a spike in the rate of correct regular marking).
> (Ambridge and Lieven 2011: 178)

Hoeffner (1996) interpreted the same data from Cazden (1968) and argued that age was a statistically significant (negative) predictor of the rate of zero-marking errors (Ambridge and Lieven 2011: 178). Considering that aging is more gradual, than sudden, Hoeffner's (1996) findings have been considered to support of the *Single Route-Model*.

According to the *Dual-Route Model*, the majority of zero-marking errors occur before the child has acquired the default rule. However, as argued above, a low rate of errors will persist even after the rule has been acquired. The claim is that zero-marked verbs may be produced by analogy with actual no-change verbs. For example producing **knit* as the past tense form of *knit*, by analogy with *hit/hit*. Here, *knit*, a regular verb, has been stored as an irregular verb, producing **knit* in past tense, while the "correct" default rule *knitted*, has been blocked by the retrieval of an irregular form. Verbs that have a similar present tense form, but do not change in past tense are phonological enemies to regular verbs such as *knit/knitted*.

Similarly, present tense verbs with stems that end in *–t* or *–d* may be erroneously stored as irregular past tense forms, as their retrieval blocks the application of the default rule. This

may also cause zero-marking errors (Ambridge and Lieven 2011: 179). An example of a zero-marking error is the production of *hate* as the past tense form *to hate*.

Both the *Single* and *Dual-Route Model* predict that zero-marking errors can be produced by analogy with irregular phonological enemies. However, the two models do not share predictions when it comes to past tense production of *regular*s. The *Single-Route Model* proposes that zero-marking errors should be rare for regular past tense forms with a high number of phonological friends and more frequent for regular past tense forms with few phonological friends. The *Dual-Route Model*, however, disagrees on the prediction that regular past tense is generated by analogy. They argue that when an irregular form is retrieved from memory, application of the regular rule will be blocked. Thus, irregular past tense production will not be vulnerable to regularization errors due to similarity to phonological enemies (Ambridge and Lieven 2011: 182).

5. Studies of Past Tense Production

5.1 Studies of Regular Past Tense Production

Whether past tense production is conducted using a *Single* or *Dual-Route* has been tested in several different studies and with different approaches. As studies of past tense production in children with SLI often are based on already existing studies on this topic, I find it necessary to refer to some central studies on regular past tense production by both children and adults.

5.1.1 Overgeneralization Errors

With different predictions as to how regular past tense is produced tests of overgeneralization errors should support either the *Single* or the *Dual-Route Model*. In this section I will review research on overgeneralization errors, and show how these mistakes have been interpreted as supporting either the generativist or the constructivist approach to language acquisition.

As described in section 4.1.4, two models differ is in relation to regularization errors caused by regular enemies. The *Single-Route Model* predicts that irregular verbs with a large number of regular enemies are more likely to be over-regularized, than irregular verbs with fewer regular enemies. While, the *Dual-Route Model* predicts that a high number of regular enemies should not cause over-regularization errors. According to Ambridge and Lieven (2011: 172-187), several studies have been conducted to test whether the *Single* or the *Dual Route Model* can best describe past tense production. Though, the studies have often emphasized other

entities than to discover whether overgeneralization errors are due to generalization of the regular or the irregular pattern. Marcus et al. (1992) and Maslen et al. (2004) consider the rate of overgeneralization. As pointed out in section 4.1.3.1 Marcus et.al found the low rate of overgeneralization errors to support the *Dual-Route Model*, while Maslen et al. (cf. section 4.1.4) maintained that the same results can be interpreted in favor of the *Single-Route Model*.

Marchman (1997) considers the influence of phonological friends and enemies on 11 regular verbs and 38 irregular verbs. Her study showed that irregular friends helped irregular verbs resist zero-marking errors, and regular friends helped regular verbs resist zero-marking errors to a similar extent. This has been interpreted as support of the *Single-Route Model* by Marchman. However, as the study did not analyze regulars and irregulars separately, the results can be interpreted as to support either the *Single-Route Model*, or to support the *Dual-Route Model* as shown in Ambridge and Lieven (2011)

> Collapsing across regulars and irregulars, zero-marking errors were more common for verbs with fewer friends. Unfortunately, regular verbs were not analysed separately but the number of friends (high/low) did not interact with the variable of regular/irregular. […] The findings of Marchman (1997) provided support for the dual-route model. Over-regularization errors were equally likely for irregular verbs with a high and low number of regular enemies. (Ambridge and Lieven 2011: 180/181)

In a later study by Marchman et al.(1999), effects of regular enemies were discovered. Such findings would support the *Single-Route Model*. This study was a comparison of past tense production in children with regular language development and children with SLI. Thus, I will come back to this study in section 5.2.2.

5.1.2 The Influence of Semantics

In a study based on five experiments, Ramscar (2002) claims that the role of semantics in past tense production has been give too little attention. Ramscar, a constructivist, argues that "inflection is carried out through analogical reminding based on semantic and phonological similarity and that a rule-based [dual] route is not necessary to account for past tense inflection" (Ramscar 2002: 45, [MEM]). Generativists, such as Pinker and Prince (1988), have claimed that the production of inflection cannot be accounted for by phonological analogy alone, a fact that gives rise to "the homophone problem" (cf. section 4.1.2). Examples

that illustrate the homophone problem are homophone verb pairs with different past tense forms such as

ring - ringed	ring - rang
brake - braked	break - broke
lie - lied	lie - lay

The answer to the homophone problem for generativists lies in grammar (rule formation). Ramscar, however, proposes a different solution to the problem, namely a difference in meaning. He proposes that verbs with similar sound and similar meaning are more likely to have the same inflection than verbs with similar sound and different meaning. Ramscar (2002) gives an example using three similar sounding verbs, the regular verb "blink/blinked", the irregular verb "drink/drank" and one novel verb "frink". He proposes that people are more likely to produce the regularly inflected form "frinked" when the novel verb appears in a context with semantic association to the regular "blink", and an irregular form "frank" in contexts with association to "drink". Ramscar (2002) tested the hypothesis that semantics influences inflection. The results showed that, by

> manipulating the semantic similarities between nonces and phonologically similar regular verbs significantly influenced the number of regular past tense forms participants produced for the nonces. When frinking had to do with consuming vodka and fish (priming drink) participants irregularized it to "frank frunk", but when frinking was a disease of the eyelid (priming wink/blink), they regularized it to "frinked". (Ramscar 2002: 83)

Based on these results, Ramscar claims that regular inflection can be formed by analogy. Due to priming, the novel regular "frinked" is formed by analogy to the existing regular "blinked".

5.2 Studies of SLI Children

5.2.1 Marchman et al. (1999)

5.2.1.1 Subjects and Method

In section 5.1.1 on overgeneralization errors, I referred to a study by Marchman from 1997. Marchman (1997) considered the influence of frequency, phonology and neighborhood

structure in regularly developing children's productivity of past tense. In a later study, Marchman and colleagues (1999) conducted a similar study, this time they included a group of children with SLI. The study represented 62 children, 31 with regular language development and 31 with SLI, who were approximately the same age (8.4 years on average). Again, the aim was to test whether phonological features in the stem might influence the inflected past tense form or if the regular rule acts independently of phonological features. The opposing propositions that Marchman et al. (1999) tested were as follows

> The dual-mechanism approach proposes that zero-markings, but not overregularizations, are predicted by both types of item-level features. Single-mechanism models, in contrast, do not make a strong distinction between regularization and irregularization, suggesting instead that similar factors should account for all types of productive language use in both [TD and SLI] populations. (Marchman et al. 1999, [MEM])

Marchman et al. (1999) presented the children with 52 English monosyllabic verbs through black and white drawings of everyday activities. They used the same test design as Berko (1958) described in section 4.1

The verbs selected were coded for verb class (25 regular and 27 irregular), frequency (high 28 and low 24)[7], stem-final phonology (17 alveolar and 35 non-alveolar)[8] and phonological neighborhood (low or high friend and enemy frequency). Table 5 and 6 presents the verbs used in the study, divided into two groups, irregulars and regulars:

[7] Frequency values were taken from speech samples (Hall, W.S., Nagy, W.E., & Linn, R, 1984) by adults corresponding to the demographics of the participants. As English regular past tense forms are generally less frequent than their irregular relatives, regulars were considered frequent if there were more than 2 occurrences, while irregulars were considered frequent if there were more than 6 occurrences.
[8] Depending on the presence of the alveolar sounds /t/ or /d/ in stem-final position

Table 5 Regular verbs used in Marchman et al.'s (1999) study

Item	Frequency	Alveolar	Friends	Enemies
Jump	High	No	High	Low
Smile	High	No	Low	Low
Spell	High	No	High	High
Try	High	No	High	High
Melt	High	Yes	Low	Low
Need	High	Yes	High	High
Spill	Low	No	High	Low
Rake	Low	No	High	High
Kiss	Low	No	Low	Low
Lean	Low	No	Low	High
Skate	Low	Yes	High	Low
Mend	Low	Yes	Low	High

Adapted from (Marchman et al. 1999: 211)

Table 6 Irregular verbs used in Marchman et al.'s (1999) study

Item	Frequency	Alveolar	Friends	Enemies	Regular Enemies	Suffix Vuln. Level
Cut	High	Yes	High	Low	Low	0
Hurt	High	Yes	Low	Low	Low	0
Hit	High	Yes	Low	High	Low	0
Bring	High	No	Low	High	Low	1
Eat	High	Yes	Low	High	High	1
Bite	High	Yes	High	High	High	1
Stick	High	No	Low	Low	High	2
Tell	High	No	High	Low	High	2
Sit	Low	Yes	High	Low	Low	1
Build	Low	Yes	Low	Low	Low	1
Ride	Low	Yes	High	Low	Low	1
Feed	Low	Yes	High	High	High	2
Draw	Low	No	Low	Low	Low	2
Sing	Low	No	High	High	Low	2
Drive	Low	No	Low	Low	High	3
Fly	Low	No	Low	High	High	3

Adapted from (Marchman et al. 1999: 211)

In the list of irregulars there is an additional column labeled "Suffix Vulnerability Level". This describes how vulnerable an irregular stem is to erroneous suffixation. The three verbs at the bottom of the list "drink", "drive" and "fly" are vulnerable by three criteria: (a) they have low frequency past tense forms ("drank", "drove", "flew"), (b) they have a high number of regular enemies, and (c) they do not have an alveolar sound in stem-final position. Low frequency past tense forms are more vulnerable because they are not used as often as high frequency forms. The constructivist argument is that forms that are not frequently occurring in the child's input are more likely to be overgeneralized. The presence of an alveolar sound

(such as /t/ or /d/) in stem-final position might be interpreted as the regular suffixes have an alveolar sound in final position (/t/, /d/, /ɪd/ or /əd/).

According to Marchman (1999: 210), verbs that are vulnerable to erroneous suffixation by three criteria are at higher risk of overgeneralization errors compared to verbs that are vulnerable to one, two or none of the criteria. One kind of erroneous suffixation of irregular verbs is regularization, where irregulars receive the regular suffix. Regularization errors should not be frequent according to the *Dual-Route Model*.

5.2.1.2 Results

The study showed that

> Items for which all three protective factors converged were the least subject to error, whereas "at risk" items were approximately three times more likely to undergo erroneous suffixation. […] Neighborhood analyses suggested that children from both groups were sensitive to patterns of phonological similarity across stems and past tense forms. In particular, an irregular verb's similarity to regular verbs increased the chances for erroneous suffixation. (Marchman et al. 1999: 216/217)

Based on these findings, Marchman et al. argue that regularization errors are caused by the same mechanism as irregularization and zero-marking errors. They occur due to inter-item similarity between phonological neighbours. The results of this study have been interpreted as an argument against the *Dual-Route Model* (Marchman et al. 1999).

According to Marchman et al. (1999) two deviant features were observed in the types of errors produced by SLI children when compared to TD children. The children with SLI were more likely to produce present tense, a progressive form or a different verb, in a context that required the simple past tense. Secondly, the SLI populations had a higher number of zero-marking errors than their TD peers. The higher rate of suffixation and zero-marking errors in children with SLI, indicate that they might be more sensitive (or over-sensitive) to phonological features in stems. For the TD population, suffixation errors were not predicted by particular phonological features in the stem. This indicates, according to Marchman et al. (1999:218), that "an over-sensitivity may interfere with efficient lexical processing and hence the organization of general patterns that obtain across individual grammatically inflected forms". To presuppose that a child needs efficient lexical processing to organize a general pattern is a constructivist view on past tense production. A generativist would argue that a

general pattern is innate, and lexical factors such as frequency or phonological neighbors, should not predict performance on regular past tense.

5.2.2 Serratrice et al. (2003)

In section 4.1 I referred to studies on overregularization in regular past tense production. The period when a child starts to produce regularization errors has been an object of interest because researchers disagree about effects of this transition in child language acquisition. Serratrice et al. (2003) conducted a study on children with SLI to investigate their use of regular and irregular past tense before and after the onset of overregularization. In contrast to Marcus et al (1992) (cf. section 4.2) who argue that regularization errors should cease immediately when the irregular form has been acquired, Serratrice and her colleagues support the constructivist approach and predicted that this process will be more gradual (Serratrice et al. 2003: 329).

5.2.2.1 Subjects and Method

Compared to the study by Marchman et al. (1999) in the previous section, this study had a smaller number of participants and a different approach to collecting data. Serratrice et al. recorded three children with SLI, while playing with their mothers at home, every fortnight over a period of about 10 months. Each session lasted about one hour. The SLI children were from 3.1-4.0 years of age when the study started. The data for the TD control group was collected from the Manchester corpus of CHILDES (MacWhinney 2000). The control group consisted of 11 children within an age range of 1.8-2.4 at the beginning of the study. All of the children were at the same level of language development measured in MLU (cf. section 2.2).

5.2.2.2 Anticipation and Results

In addition to considering the onset of overregularization, the researchers aimed to describe the distribution pattern of past tense forms used by SLI and TD children. They wanted to find out which verb class was the most frequent, whether children used finite forms in obligatory contexts, and whether the verbs that are most frequent in adult speech (measured by the speech supplied by the mothers)[9], were also most frequent in the children's speech.

[9]Due to lack of research on a possible difference between the input given to children with SLI and TD children, only the input of mothers of TD children was used in this study.

The observation of the children's production of past tense forms showed that irregulars have both a higher token and type frequency than regulars. Token frequency refers to the number of times one specific verb occurs (for example *sang*), while the type frequency refers to the different kinds of phonological analogies (for example *sang* and *rang* are two tokens that belong to the same type of analogy). About 75% of all the past tense tokens the children produced were irregular. This is similar to the distribution of regulars and irregulars in the input the children received (Serratrice et al. 2003: 338).

Based on these results, Serratrice et al. (2003) argue that distribution patterns of past tense verbs may be influenced by maternal input. A second claim is that past tense production might not be as different in children with SLI and TD children, when the two groups are compared on MLU. These are interesting results, and they clearly challenge the hypothesis by Rice et al. (2000) (cf. section 3.3), according to which children with SLI should be similar to MLU controls on irregular past tense production. However, they would perform worse on regular past tense due to an extended optional infinitive phase. Serratrice et al. (2003) argue that this may be due to the young age of the participants and the differences in language production between TD and SLI children may increase with age.

In Serratrice et al's (2003) study, one SLI child (Nathan) and four MLU controls had started to produce overgeneralization errors. The results showed no increase in the use of regular past tense forms in obligatory contexts for the children who had started to use overregularizations:

> If overregularization marks a "qualitative shift in the child's mental representation of finiteness and obligatoriness of tense marking", the expectation would be that any regular verb would be appropriately tense-marked, and at least any irregular verb without a sufficiently entrenched correct past tense form would be a candidate for overregularization. This is, however, not the case either for Nathan or for any of the other unaffected children (Serratrice et al. 2003: 344).

Serratrice et al. (2003), consider their results an argument against the rule-governed theory of the *Dual-Route Model*. The children did not appear to have created an across-the-board rule as overregularaization did not lead to a higher frequency of regular verbs in obligatory contexts. On the contrary, these results indicate that overregularization is a lexical phenomenon driven by analogy and schema formation.

5.2.3 Van der Lely and Ullman (2001)

Constructivists and generativists have entirely different claims as to how children acquire past tense morphology (cf. section 2.1.3). Van der Lely and Ullman (2001) claim that the two approaches also have different hypotheses as to what causes impaired past tense production in children with SLI. According to the *Single Route-Model*, SLI is considered an input-processing deficit, while the *Dual-Route Model* would label it a grammar specific deficit. The *Single Route* approach would label SLI an input-processing deficit due to limited processing capacity.

> SLI can be traced to a deficit in the rate of auditory processing that is not language-specific […] this auditory perceptual deficit causes SLI children to have problems perceiving morphemes such as *-ed* or *-s*, which have 'low perceptual salience'. Therefore, additional resources are required to perceive such morphemes, which causes further difficulties learning morphological paradigms. (Van der Lely and Ullman 2001: 182)

The *Single-Route Model* predicts that SLI children have a general impairment across regular and irregular past tense forms when compared to TD children of the same age.
However, if SLI children are compared to a vocabulary matched control group, the children's inflectional morphological performance should not differ (Van der Lely and Ullman 2001: 184).

According to the *Dual Route Model*, however, Van der Lely and Ullman (2001: 183) argue that "aspects of language that rely on grammatical processes may be impaired while those that rely on other processes, such as associative learning and memory, may be spared". The grammar-specific deficit hypothesis predicts that SLI children store both regular and irregular forms in the lexicon, due to difficulties computing the regular past tense rule. Thus, children with SLI should show a similar performance on regular and irregular past tense production. This should differ from the past tense production of vocabulary matched TD children, who should be better at producing regular past tense forms, which are rule produced, than irregulars, which are retrieved from memory (Van der Lely and Ullman 2001: 185).

5.2.3.1 Subjects and Method

To be able to test the two models, Van der Lely and Ullman (2001) compared past tense production of irregular and regular past tense forms in SLI children and three control groups of TD children. The group of SLI children belonged to a subgroup known as G-SLI, or Grammatical-Specific Language Impairment. Van der Lely and Ullman (2001) considered this subgroup to be a more homogenous group than a random group of SLI children. They argued that Children with G-SLI are better suited for a grammatical analysis of past tense production due to a primary deficit in the computational system. The three control groups consisted of children who were all younger than the SLI children. Group I had a mean age of 5.9, Group II of 6.11, and Group III 7.11. The mean age of the SLI children was 11.2 years. All four groups completed four tests, testing different aspects of grammatical ability.

The fours tests were

- *The Test for Reception of Grammar* (TROG),
- *Grammatical Closure sub-test, Illinois Test of Psycholinguistic Abilities* (GC-ITPA),
- *British Picture Vocabulary Scales* (BPVS)
- *Naming Vocabulary, British Ability Scales* (NV-BAS).

GC-ITPA is a test of morphological production which includes regular and irregular morphology, while TROG is a test of sentence comprehension. They both test lexical and grammatical knowledge. BPVS and NV-BAS expression and comprehension of single words (Van der Lely and Ullman 2001: 187/188). The results of the tests are shown in Table 7:

Table 7 Chronological age and raw scores from four standardised tests used for matching G-SLI children with the control children

	G-SLI children (nˆ12) Mean (SD)	*LA1 controls (nˆ12) Mean (SD)*	*LA2 controls (nˆ12) Mean (SD)*	*LA3 controls (nˆ12) Mean (SD)*	*Summary of analysis between groups*
Chronological age	11:2 (1:1)	5:9 (0:4)	6:11 (0:4)	7:11 (0.5)	
Range	9:3–12:10	5:5–6:4	6:5–7:4	7:5–8:9	
TROG	13.08 (1.78)	14.41 (8.56)	16.00 (1.75)	17.33 (1.23)	LA1= G-SLI<(LA2=LA3)
GC-ITPA	20.00 (3.56)	21.25 (3.16)	26.25 (4.08)	28.91 (2.19)	LA1= G-SLI<(LA2=LA3)
BPVS	78.83 (8.93)	56.25 (8.91)	71.67 (9.71)	80.00 (9.62)	LA1< G-SLI=(LA2<LA3)
NV-BAS	17.91 (1.17)	15.67 (1.61)	17.17 (1.27)	17.50 (0.90)	LA1< G-SLI=(LA2=LA3)

(Van der Lely and Ullman 2001: 187)

Group I (LA1) matched the SLI children on GC-ITPA and TROG. GC-ITPA tests morphological production while TROG tests sentence comprehension. However, on the expressive and receptive tests of single word vocabulary knowledge, BPVS and NV-BAS, Group I scored significantly lower than the SLI group. For the two latter tests, the SLI children matched the older control groups, i.e. Group II and III. Group II and III scored higher than the SLI children on the two tests relating to morpho-grammatical ability (Van der Lely and Ullman 2001: 188).

The test design of this study is similar to the "*Wug* test" by Jean Berko (1958) (cf. section 4.1). However, in this study the test contained 60 verbs. The verbs belonged to four classes, regulars, irregulars and two types of novel verbs. The regular and irregular group contained verbs that were 50 percent high past tense frequency and 50 percent low past tense frequency. The novel verbs were divided into two groups: one group contained verbs whose stems were phonologically similar to the stems of real irregular verbs, and thus could take irregular or regular past tense forms, e.g. *crive-crove/crived* which has similar phonology to the existing irregular *drive-drove*. The second group of novel verbs contained verbs with stems that are phonologically dissimilar from the stems of all irregulars, and similar to the stems of regular verbs. These were considered "novel regular" verbs (Van der Lely and Ullman 2001: 188/189).

5.2.3.2 Results

Van der Lely and Ullman (2001) described a dichotomy of what the two Models would expect. If vocabulary-matched TD children were better at producing regular past tense, than irregular, while SLI children were equally good (or bad) at both forms, this would support the *Dual-Route Model*. However, if the *Single-Route Model* should be supported, both vocabulary-matched groups should have similar performance on regular and irregular past tense production.

> For novel irregular verbs (*crive*) the control children generally produced significantly more regularisations (c*rived*) than irregularisations (*crove*). In contrast, the G-SLI children produced regularisations and irregularisations at similar rates. For novel regular verbs all the groups produced fewer irreguarisations than regularisations (Van der Lely and Ullman 2001: 199).

The researchers concluded that there was a difference between the two vocabulary-matched group's past tense production. This argument supports the *Dual-Route Model*. However, it is necessary to take a closer look at different findings that led to this conclusion.

5.2.3.2.1 Lexical effects

This study, like the study by Ramscar (2002) (cf. section 5.1.2) considered lexical effects on production of regular, irregular and novel verbs. Their findings are similar to Ramscar's (2002) findings in that lexical effects influenced the children's production of novel irregulars. That is to say that, "[t]he control groups, generally produced irregularizations for irregular

rhyming novel verbs" (Van der Lely and Ullman 2001: 200). However, the results were not similar when considering lexical effects on regular verbs. Here, the younger TD children showed only a few lexical effects, while the two older groups (LA2 and LA3) showed no frequency effect for regular past tense production. These results are difficult to interpret within the *Single-Route Model*. The *Dual-Route Model*, however, allows Van der Lely and Ullman (2001) to provide an explanation:

> The data indicate that for normally developing children regular past tense forms are rule products and so are not significantly affected by the properties of lexical memory (frequency and their sound patterns). Therefore, the regular rule applied as the default whenever memory access fails, can account for the greater number of regularisations than irregularisations produced for novel verbs – which was found even for those novel verbs that do not sound like existing regular verbs (i.e., for a subset of the irregular novel verbs).
>
> (Van der Lely and Ullman 2001: 203)

Showing that lexical effects did not cause regularization of novel verbs is a strong argument in support of the generativist *Blocking and Retrieval Failure Hypothesis* (cf. section 4.1.3.1).

One of the TD control groups provided the researchers with a result that did not support the generativist approach. Van der Lely and Ullman (2001) discovered that the LA1 controls showed a weak frequency effect on regular verbs. They argue that a possible explanation could be that memorized forms are causing the effect "by facilitating access to and keeping in memory the stem form during the process of adding the affix" (Van der Lely and Ullman, 2001: 203). This assumption was tested in an analysis where stem frequency was eliminated as a factor. Now, the correlation between past-tense frequency and correct production of regular forms was no longer significant for the younger LA1 group. According to Van der Lely & Ullman (2001: 203) research (Gathercole, Service, Hitch, Adams & Martin, 1999) on the development of phonological long and short-term memory supports this claim. Younger children use long-term memory to recall stems, as they have not yet developed a fully functional short-term memory. In section 5.2.4 I will come back to research on phonological short-term memory.

5.2.3.2.2 Unmarked forms

As a response to the studies by Marchman (1997, 1999), Van der Lely and Ullman (2001) considered unmarked forms and frequency effects of phonological neighbours. In Marchman et al.'s studies (1997, 1999), only known verbs were considered for phonological neighborhood effects. The benefit of considering novel verbs as well, as Van der Lely and Ullman did in their study, is that these past tense forms will be produced for the first time. Novel past tense forms have not been rote learned, as other past tense forms may have been. This makes them well suited for testing whether or not regulars and irregulars are both acquired by analogy to similar sounding past tense forms.

As mentioned above, Van der Lely and Ullman (2001) labeled the verb *novel regulars* and *novel irregulars*. They were considered to be regulars and irregulars based on phonological and lexical similarities to known verbs. Thus, for example, they offered the *novel regulars* "dotch", "brop" and "plam" in contexts in which they could be associated with known verbs. "Dotch" is phonetically similar to the regular verb "watch". In the study, "dotch" was presented in a context with the complement "your car". Some of the novel verbs used in Van der Lely and Ullman's study are presented in Tables 8 and 9.

Table 8 Novel regulars and similar known verbs from Van der Lely and Ullman (2001)

Present/past tense form	Lexical Similarity	Phonological Similarity
Dotch/ed	Yesterday I dotched your car	/dɒtʃ/ /dɒtʃt/
Watch/ed	Yesterday I watched your car	/wɒtʃ/ /wɒtʃt/
Wash/ed	Yesterday I washed your car	/wɒʃ/ /wɒʃt/
Brop/ped	Yesterday I bropped my jacket	/brɒp/ /brɒpt/
Drop/ped	Yesterday I dropped my jacket	/drɒp/ /drɒpt/
Plam/med	I plammed my leg	/plam/ /plamd/
Slam/med	I slammed my leg	/slam/ /slamd/
Jam/med	I jammed my leg	/dʒam/ /dʒamd/

Table 9 Novel irregulars and similar known verbs from Van der Lely and Ullman (2001)

Present/past tense form	Lexical Similarity	Phonological Similarity
Crive/Crove	Yesterday I crove a lot	/krʌɪv/ /krəʊv/
Drive/Drove	Yesterday I drove a lot	/drʌɪv/ /drəʊv/
Scrit/Scrat	Yesterday I scrat for Steve	/skrɪt//skrat/
(Baby)Sit/Sat	Yesterday I (baby)sat for Steve	/sɪt//sat/
Strink/Strunk	Yesterday the magician strunk a horse	/stɪŋk//strʌŋk/
Shrink/Shrunk	Yesterday the magician shrunk a horse	/ʃrɪŋk//ʃrʌŋk/

As reported in section 5.2.1.2, Marchman and colleagues (1999) argue that both regular and irregular past tense patterns are influenced by phonologically similar friends and enemies. This finding was corroborated in Van der Lely and Ullman's (2001) study when they included novel verbs. The four group's production of unmarked forms for novel and known verbs can be seen in Table 10 and 11:

Table 10 Unmarked novel verbs

Verb class	G-SLI	LA1	LA2	LA3
Novel regular	**56.8%**	**33.3%**	**20.1%**	**15.3%**
Novel irregular	**59.1%**	**39.9%**	**28.0%**	**29.8%**

(Van der Lely and Ullman 2001: 192)

Table 11 Unmarked known verbs

Verb class	Frequency	G-SLI	LA1	LA2	LA3
Novel regular	**High**	**60.2%**	**29.2%**	**22.9%**	**19.8%**
	Low	**70.5%**	**39.6%**	**22.9%**	**16.7%**
Novel irregular	**High**	**67.5%**	**35.7%**	**7.1%**	**19.0%**
	Low	**73.9%**	**51.0%**	**21.9%**	**52.0%**

(Van der Lely and Ullman 2001: 191)

Based on these results, Van der Lely & Ullman (2001: 201) maintain that there is "a tendency to produce more unmarked forms for the real and novel irregular verbs than for the real and novel regular verbs". These findings neither support the *Single-Route Model*, or do they substantiate the claim that both forms are influenced to a similar extent by phonological neighbors. According to the *Dual-Route Model*, however, only irregulars are retrieved from memory, and thus are prone to influence by phonological neighbors. That the regular suffix "-ed" is applied per default whenever memory access fails, may explain a higher number of regularizations than irregularizations produced for novel verbs (Van der Lely and Ullman 2001: 203). Thus, the results of Van der Lely and Ullman's study support the *Dual-Route Model*.

5.2.3.3 Differences between SLI children and TD controls

When comparing typical and impaired language acquisition, the Single and Dual-Route

approach offers different explanations as to what causes SLI. Is it an input-processing deficit or a grammar-specific deficit? Van der Lely and Ullman (2001) considered both models when analysing their results. Initially, they found results that may support the Single-Route Model's explanation of an input-processing deficit. "[1] The G-SLI children's use of unmarked forms in past tense contexts, [2] their particular impaired production of regular past tense marking in comparison to the control children, and [3] their limited ability to generalise the regular past tense marker to novel forms" (Van der Lely & Ullman 2001: 201). These three findings are consistent with the hypothesis that children with SLI have an auditory perceptual deficit, causing them to have problems perceiving, and thus acquiring, the regular "-ed" suffix.

However, with further investigations, the researchers found their results to be inconsistent with the Input-Processing Hypothesis. According to this hypothesis, SLI children would produce a higher number of unmarked forms for the regular known and novel verbs, due to a impaired processing of the "-ed" morpheme. This was not supported in the study. "The production pattern of unmarked forms across known and novel regular and irregular verbs was similar for the G-SLI children and LA controls" (Van der Lely & Ullman, 2001: 202).

Another area, where the results did not support the Input-Processing Hypothesis, concerns the prediction that children with SLI would perform in qualitatively and quantitatively similar ways to children matched on language abilites (Van der Lely & Ullman, 2001: 202). In this study, the SLI children were compared to three groups of language controls. Group I (younger TD children) matched the SLI children on morpho-grammatcial ability, while group II and III (older TD children) matched the SLI children on single-word vocabulary comprehension and expression. Despite these similarities between the TD children and the SLI children, the study showed that "[t]he G-SLI children's overall pattern of use of irregular and regular morphology does not appear to match that of children at any stage of normal language development" (Van der Lely & Ullman, 2001: 202). These findings are difficult to interpret within the *Single-Route Model*. According to the *Single-Route Model*, SLI children's production of inflectional morphology should not be different from a vocabulary matched control group (cf. section 5.2.3).

As the results in the study did not support the Input-Processing Hypothesis, the researchers compared the results to the Grammar-Specific Hypothesis, according which, children with SLI should show a similar performance on regular and irregular past tense production, while TD children should be better at producing regular past tense forms, than irregulars. These

expectations are borne out:

Table 12 Mean responses rates (as % of items) for high and low frequency regular and irregular verbs

Verb class	Frequency	G-SLI	LA1	LA2	LA3
Regular verbs	**High**	**33.0%**	**66.7%**	**71.9%**	**80.2%**
	Low	**11.4%**	**48.9%**	**72.9%**	**76.0%**
Irregular verbs	**High**	**19.9%**	**34.5%**	**70.3%**	**59.5%**
	Low	**13.6%**	**18.6%**	**42.7%**	**41.7%**

(Van der Lely & Ullman, 2001: 191)

The children with SLI had a more similar production of regular and irregular (high and low frequency) past tense verbs (33.0%, 11.4%, 19.9% and 13.6%), compared to the TD children's past tense production. The TD children showed an advantage for regular (66.7%, 71.9%, 80.2%, 48.9%, 72.9%, 76.0%) verbs compared to irregular past tense production (34.5%, 70.3%, 59.5%, 18.6%, 42.7%, 41.7%).

Considering these results, Ullman and Van der Lely argue that SLI children, have an impairment "in the grammatical computations underlying the *–ed* sufixation rule [and] tend to memorise regular as well as irregular past tense forms" (Van der Lely & Ullman, 2001: 205). According to the Dual-Route Model, overgeneralisation occurs when children fail to retrieve the correct irregular past tense form, and produce the regular, rule-based form instead. The hypothesis, according to the Dual-Route Model would then be that G-SLI children, who have a dysfuntional or impaired use of the rule, should overregularise less than the TD controls. This hypothesis was supported in the study, "analysis revealed the G-SLI children produced significantly fewer over-regularisations than the younger LA2 control children [...] and than the vocabulary mathed LA2 and LA3 control children" (Van der Lely and Ullman 2001: 196).

5.2.3.4 Conclusion

Van der Lely and Ullman (2001) conclude that their results support the Grammar-Specific Hypothesis. However, they argue that it may be more accurate to refer to the grammatical mechanisms of rule formation in children with SLI as impaired, rather than missing. Van der Lely's (1998) hypothesis is known as the *Representational Deficit in Dependent Relations* (RDDR), which claims that "G-SLI children's syntactic deficits are caused by a deficit in the computational grammatical system such that grammatical-structural rules, by definition

obligatory in normal grammar, are optional in G-SLI grammar" (Van der Lely and Ullman 2001: 206). This assumption can explain why the SLI children produce such a high number of unmarked forms in past tense contexts.

The results show that G-SLI children accept the correctly inflected form (e.g, *came*), the incorrectly inflected form (e.g., *comed*), and the uninflected form (e.g., *come*) in past tense contexts. These errors suggest that the child stores the past tense form of irregular verbs, but the blocking mechanism, that would prevent a regular infelction being affixed to a stem, for a TD child, appears to be optional for the G-SLI child (Van der Lely and Ullman 2001: 204). This explains why children with G-SLI produce regularisation errors, even after they appear to have acquired the blocking mechanism. As previously argued, according to the generativisit account, regularisation errors should cease when the irregular form has been acquired (cf. section 4.1.3.1).

5.2.4 SLI, Impairment in Working Memory?

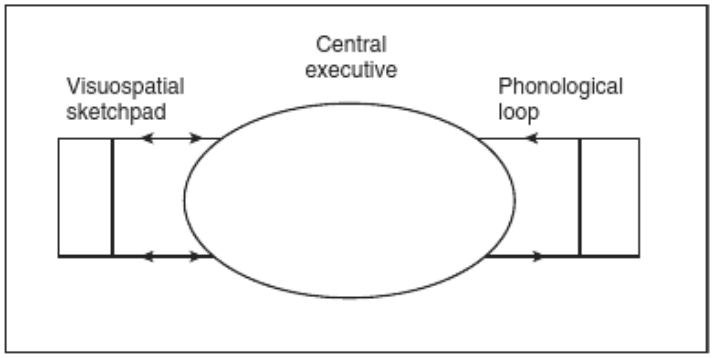
The question of whether SLI is related to impaired auditory processing, or should be considered a more grammar specific impairment, has been researched by Gathercole and Baddeley (1990). They argue that children with SLI struggle to acquire language due to limitations in the phonological short-term memory system. Their hypothesis has been supported through research where they asked children to repeat novel words, such as "blonstertaping" or "dopelate" and discovered that SLI children have significant limitations in production of novel words, compared to control groups[10]. As these words were unknown to the children, they had to rely on short-term memory to recall them.

Short-term memory (STM) is a central part in the process of receiving and storing phonological input. STM is often contrasted to long-term memory. It was previously claimed that information was stored, first temporarily in the STM, while later, more permanently stored in long-term memory (Baddeley 2007: 2). In the 1960s and 70s, a third term was introduced, the working memory. The difference between STM and working memory is that STM is used when we immediately recall small amounts of information, while the working memory is a broader system used for attentional control and allowing manipulation of information held in the STM (Baddeley 2007: 7). According to Baddeley and Hitch (1974),

[10] One group matched the SLI children on vocabulary ability, while the others were matches on non-verbal intelligence.

the working memory consists of three components, the *visuo-spatial sketch pad*, the *central executive* and the *phonological loop*[11].

Figure 4 The three component working memory model proposed by Baddeley and Hitch (1974)



(Baddeley 2007: 8)

The *phonological loop* and *visuo-sptatial sketch pad* are subsidiary storage systems to the *central executive. The phonological loop* holds speech-based and possibly acoustic information, while the *visuo-spatial sketch pad* holds visual and spatial information. The *central executive* is the attentional control system receiving and contributing information to and from the other systems (Baddeley 2007: 7). According Baddeley, the function of the "phonological loop is to provide temporary storage of unfamiliar phonological forms while more permanent memory representations are being constructed" (Baddeley 1998: 159).

As, the *phonological loop* plays an important part in language acquisition, it has been central in studies of impaired acquisition. Research has shown that memory limitations may be a cause of language impairment (Baddeley 1998: 165). It has been debated whether poor language skills cause poor verbal memory or vice versa. One way of determining what is cause and what is effect, is to test SLI children's verbal memory and compare the results with those of a language matched, younger control group. If SLI children's memory is poor in relation to a language-matched younger control group, it can be argued, that the problem is not just a secondary consequence of language limitations. As reported by Baddeley and colleagues (1998: 165), research results have been mixed. One study, by Leonard and Schwartz (1985) showed that SLI children at the one-word stage of acquisition had similar performance on memory tasks as younger MLU-matched controls. Another study, i.e. Haynes

[11] More advanced models have been developed since 1974, but the level of detail in the newer models is not relevant for my thesis.

(1982), showed that older SLI children preformed poorer on memory tasks, than TD language-matched controls. The study by Leonard and Schwartz (1985) indicates that the gap in verbal memory performance, between SLI and TD children, grows with age. The latter result indicate that poor verbal memory cause poor language skills.

5.2.4.1 Maillart & Schelstraete (2002)

Maillart & Schelstraete (2002) have conducted a study to determine whether SLI is an input processing deficit- or a grammatical deficit. They argue in favor of a working memory overload hypothesis, i.e., an input processing deficit. In their study, SLI children and TD, age and language matched, controls were presented with sentences with constant level of syntactic complexity, while the load on working memory varied. Maillart and Schelstraete (2002) proposed that, if the impairment in SLI is specifically syntactic, i.e. according to the grammatical deficit hypothesis, the participants would have the same performance whatever the load on working memory (as was the case for the control group). However, if the load on working memory was the critical factor, i.e. according to the memory overload hypothesis), the researchers expected to see different profiles as a function of working memory load variations (Maillart & Schelstraete 2002: 87).

The researchers tested sentence comprehension in French speaking children. The children were presented with spoken sentences (from an audio file), followed by an image on a computer screen, and three different response buttons (with images of a house, a sun and a duck). For each sentence, the children were supposed to push the button that corresponded with the sentence and image. The sentence was presented prior to the image, thus the child had to keep information in working memory to be able to press the correct button. Sentences were built on the model: "Push the button... when you see a…" To increase the load on working memory information was added, and the position of the subordinate clause altered (left branching sentences are considered more complex than right branching in French).

The results from the study showed that the age controlled group was not affected by the increase in load on working memory. However, the younger language matched children, and the SLI children were affected by the overload. The SLI children were influenced to a larger extent than the language matched control group.

Below are the results of the SLI children (with initials J.C., A.G. and F.R.) responses. They are ordered in percentages of correct responses from six series. The SLI children are matched with age (AC) and language (AL) controls.

Table 13 Percentage of correct responses by series, SLI children matched with age and language controls

	Series 1	Series 2	Series 3	Series 4	Series 5	Series 6
J.C.	100	70	51.7	20	34.2	22.5
AC	100	86.7	92.9	91.4	93.7	87.5
AL	100	78.6	63.3	77.9	74.3	59.2
A.G.	100	60	50	34.8	38.7	30
AC	100	89.2	90.6	92	89.8	90.6
AL	100	73	59.8	69.4	70.4	55.5
F.R.	100	70	51.4	59.4	51.4	57.5
AC	100	87.5	93.7	90.6	94.5	86.2
AL	100	82	81.7	80.2	81.7	78.5
M.H.	100	56.7	40	-	53	40
AC	100	85.8	89.8	90.6	92.2	85.6
AL	100	73	59.8	69.4	70.4	55.5
V.M.	100	80	78.1	81.2	90.6	62.5
AC	100	89	89.1	91.2	89.1	88.1
AL	100	82	81.9	80.2	81.9	78.2

(Maillart & Schelstraete 2002:91)

The data show that SLI children produce non-uniform results. J.C. and A.G. were more affected than the other SLI children by the amount of information to be kept in working memory. This was tested in series 2 and 6. F.R., M.H and V.M., however, were sensitive to the order of the elements (left- or right-branching structures). This was tested by considering the responses from all series and subtracting the percentage of correct responses for left-branching sentences from the percentage obtained for right-branching. A subordinate clause at the beginning of a sentence (such as "When you see a …., push on the button"), does not create the same load as having the subordinate clause at the end of the sentence (as in "Push on the button… when you see…).

Maillart & Schelstraete (2002) also tested phonological effect and the effect of morphosyntactic cues. An example of a morphosyntactic cue, is the suffix *–s* on an English noun which indicates that the noun is plural.[12] For a child who has acquired the inflectional suffix on plural nouns, the appearance of the s-suffix is a morphosyntactic cue. Lightfoot (2006) argues that a cue is a piece of structure derived from input. It is not the suffix *–s* itself which is the cue, though the suffix expresses an underlying grammatical structure.

> As a child understands an utterance, even partially, he/she has some kind of mental representation of the utterance; that involves a syntactic structure, which helps to define meaning. The learner scans those representations, derived from the input, and finds the necessary elements of structure, cues (Lightfoot 2006 : 78).

Lightfoot's claim of a mental representation of syntactic structure is a generativist approach to language acquisition.

The effect of morphosyntactic cues on working memory is that they reduce the amount of information kept in working memory, as the knowledge of inflectional suffixes is already known (Maillart and Schelstraete 2002 : 93). In series 3 the images on screen showed one or several boys, while in series 4 the images showed one or more girls. In French, singular definite form of boy is *le garcon*, while plural form is *les garcons*. The singular definite form of girl is *la fille*, while plural is *les filles*. The phonological difference between the articles *le/les* in *garcon/s* is less salient than *la/les* in *fille/s*. The researchers hypothesized that the more salient distinction between articles *la/les*, would be easier to process, than the less distinctive difference between *le/les*. The more salient, feminine form would provide

[12] There are exceptions, e.g. nouns with *s* in final position of the root (i.e. *bus*), and irregular nouns that form plural without the s-suffix (i.e. *men*).

morphosyntactic cue effects, which would reduce the burden on working memory. When the researchers compared series 3 and 4 they found that three of the SLI children and all children in the control groups performed better with the morphosyntactic cues. However, two of the SLI children J.C. and A.G. showed a reversed performance compared to the other children. To them, the morphosyntactic cues seemed to induce an overload, instead of relieving working memory.

According to Maillart & Schelstraete (2002: 94) the result is an argument against the grammar specific hypothesis. The linguistic challenge in their test did not vary, only the load on working memory. As this factor influenced SLI children's performance to a larger extent than language, and age-matched controls, the researchers claim that SLI is not an entirely grammatical impairment. For SLI children the burden on working memory appears to interact with language processing, and cause poorer performance on linguistic tasks.

In section 7.4 I will discuss how the results of Maillart and Schelstraete's (2002) study influence the past tense debate between generativists and constructivists.

6. Biological Foundations

6.1 Genetic Influence on SLI, Bishop et al. (2006)

According to Bishop et al. (2006: 158), the evidence for genetic influence on SLI is so strong that few would dispute it. This has been supported by several twin studies such as Bishop et.al (1995), Lewis & Thomson (1992) and Toblin & Buckwalter (1998). A benefit of twin studies is that one can compare monozygotic and dizygotic twins. Monozygotic twins are genetically identical, while dizygotic twins have, on average, only 50% alleles in common.[13] This makes it possible to compare two groups of children who have grown up in the same environment, but with either a different (dizygotic) or identical (monozygotic) set of genes. If genes affect a trait, the monozygotic twins will be more similar to each other, than the dizygotic twins. Studies of SLI have shown that if one monozygotic twin has SLI, there is a 70-96% probability that the other twin will also show evidence of language impairment. Compared to a pair of dizygotic twins, the probability is much lower, about 46-69%.

[13] Each of two or more alternative forms of a gene that arise by mutation and which may be found in the same position on a homologous chromosome (OED)

Although there is agreement that genes influence language development, the nature of the inherited deficit causing SLI, has not been established. Are genes causing deficits in the phonological short-term memory (cf. Baddeley (1998), section 5.2.4), or could they explain why some children show signs of a prolonged optional infinitive phase (cf. Rice et al. (1995) section 3.3)? Baddeley's and Rice et al.'s theories describe different manifestations of SLI. Are they different outcomes of the same underlying impairment, or do they correspond to two etiologically distinct subtypes of SLI? These are questions asked by Bishop et al. (2006), in a study of 6-year old twins. They aimed to discover whether deficits in non-word repetition and verb inflection use were of one or several genetic origins.

6.1.1 Subjects and Method

Bishop et al. (2006 : 160) tested 173 twin pairs, of which ca. 10% where categorized as *at risk of language impairment* ("LI risk"). Due to the large sample size, the twins were not given an individual language test. Thus, the "LI risk" assessments were taken by the twin's parents. This has proven to be an effective method for identifying children who obtain low language scores when seen for individual testing (Oliver et al. 2004). The parents provided information on vocabulary size, grammar rating (were the children using full sentences) and whether or not they believed their child's language was developing slowly.

The test consisted of the following subtests:

- *The Wechsler Abbreviated Scale of Intelligence* (WASI) (Wechsler 1999) testing intelligence.
- *The Clinical Evaluation of Language Fundamentals – Revised* (CELF-R) (Semel et al. 1987) measuring receptive language through listening to paragraphs and sentence structure. It also consists of an expressive subtest of STM where the child recalls sentences.
- *The Children's Nonword Repition Test* (Gathercole et al. 1994). The child listens to a digital talking monster using a computer and headphones, and repeats the novel words.
- *The Rice-Wexler Test of Early Grammatical Impairment* (Rice and Wexler 2001). Here the children's use of inflected forms is tested. They encourage the children to use past tense or third person singular by showing images and asking questions. For past tense production the researcher shows and image of a boy performing an action (for example *raking*), and says "Here the boy is *raking* (VERBing); now he is done. Tell

me what he did". Incorrect inflections, such as overgeneralizations of irregular verbs (*runned* for *ran*) were included in the total of inflected forms[14] (Bishop et al. 2006 : 160/161).

6.1.2 Results

The results of the language tests conducted with six-year old twins are presented in Table 14. Note the mean scores on the different language tests for children who were considered to be either low risk, or at risk of language impairment (LI risk):

Table 14 Mean scores on test battery for low risk and LI risk children

	Low risk	LI risk
	n = 183	n=163
Performance IQ	100.9 (11.22)	97.7 (10.79)
Verbal IQ	101.0 (13.21)	93.3 (12.52)
Listening to paragraphs*	99.8 (13.62)	94.6 (15.41)
Sentence structure*	99.5 (13.00)	92.6 (12.68)
Recalling sentences*	97.0 (12.43)	86.7 (13.82)
Nonword repetition scaled	96.6 (17.07)	85.1 (18.13)
% verbs inflected (raw)	94.9 (10.08)	88.2 (18.39)

LI risk, risk of language impairment

*Subtest from CELF-R; scores rescaled to mean of 100 and SD 15 for comparability with other tests Adapted from (Bishop et al. 2006: 161)

The table shows that children who were considered to be at risk of language impairment performed significantly poorer on all of the language tests. The mean score of the LI risk children is below 100 (the normative mean), while the low risk children have a higher mean score on all tests (laying closer to the normative mean). Thus, the low risk population is representative of the general population, and the chosen language tests are effective for identifying impaired language processing and production.

[14] Whether or not it is the correct finite form is not as important here as it would be, for example in a test of (over)regularization errors. The Optional Infinitive Theory's (Rice et al. 1995) main concern is to discover if the child is using finite verbs in finite contexts.

By comparing the test results of monozygotic and dizygotic twin pairs, Bishop et al. (2006) discovered that STM is a good marker of heritability in SLI, as it reduced the use of verb inflections (seen in children who showed an *Extended Optional Infinitive Phase* beyond the age of 4). However, there was no evidence found for a genetic overlap between measures of verb inflections and phonological STM. Thus, an *Extended Optional Infinitive Phase* cannot be considered a consequence of limitations of the phonological STM, rather the two have different genetic origins.

The *CELF-R Sentence Structure* subtest revealed suggestive evidence of a common genetic influence on both the use of verb inflections (*Rice-Wexler test of Early Grammatical Impairment*) and the ability to understand grammatically complex sentences (*CELF-R*). *CELF-R Sentence Structure* is a test that assesses understanding, and does not require the child to produce language. The data suggests that "the genes that affect grammatical development may be implicated more generally in computation of syntactic relationships, rather than solely impacting on use of verb inflections" (Bishop et al. 2006: 166). These findings concur with Van der Lely's *Representational Deficit in Dependent Relations Theory* (RDDR) (cf. section 5.2.3.4). According to *RDDR* there is a subgroup of SLI, Grammatical-SLI, characterized by a deficit in the computational grammatical system, causing grammatical-structural rules, to be considered optional.

Van der Lely characterizes Grammatical SLI as:

> "A significant impairment (more than 1.5 SD) on one or more standardised tests tapping grammatical abilities involving sentence understanding and expression alongside vocabulary impairment. In addition, on specific tests tapping those aspects of morpho-syntax core to the deficit in G-SLI (e.g. tense & agreement, Wh-questions, assigning theta roles in passive sentences and intra-sentential pronominal reference) [a] group of G-SLI children were significantly worse than normally developing children of 5–6 years-old (Van der Lely et al. 2004: 171)

6.1.3 Conclusion

According to this study, both limitations of phonological STM and impaired capacity of carrying out grammatical computations are phenotypic markers of heritable language

impairment.[15] The two markers did not overlap in the twin population, thus there must be (at least) two genes implicated in causing SLI (Bishop et al. 2006: 156).

How is Bishop et al.'s study relevant to the discussion between generativists and constructivists? The findings of their study could shed light on the debate on whether SLI is an input-processing deficit, or a grammar specific deficit. In the study, children who were considered at risk of language impairment had reduced capacity to reproduce novel words and carry out grammatical computations. However, the two kinds of impairment were not present in all of the children in the LI risk group. It could be the case that some children have a reduced STM causing SLI, while others have reduced capacity to preform grammatical computations, also causing SLI. Some children may have reduced performance in both areas of language processing, but the main claim, from Bishop et al. (2006), is that there is no etiological overlap between the two deficits.

According to Bishop et al. (2006), the fact that there is more than one kind of genetic influence on SLI is an argument against the generativist claim of a grammar specific deficit.

> The current study expands the list of factors that seem inadequate to account for grammatical impairments: the heritable deficits in verb inflections and syntactic comprehension seen in our sample cannot be explained in terms of weak phonological STM, low IQ, poor articulation or vocabulary limitations. Thus, most of the domain-general candidate explanations that have been put forward to explain grammatical deficits in SLI are inadequate to account for this pattern of results (Bishop et al. 2006: 167).

These claims are not clearly constructivist, yet they claim that a generativist approach is not supported in their study.

6.2 Regular and Irregular. A False Dichotomy?

A central aspect of the past tense debate between *Single* or *Dual-Route* accounts is the premise of two distinct forms, regulars and irregulars. Either, the two are produced in a similar manner, the *Single-Route Model*, or by two separate mechanisms, the *Dual-Route*

[15] According to the Oxford English Dictionary, a phenotype is "[t]he sum total of the observable characteristics of an individual, regarded as the consequence of the interaction of the individual's genotype with the environment; a variety of an organism distinguished by observable characteristics rather than underlying genetic features" (OED).

Model. However, in the last decade, the regular-irregular dichotomy has been challenged. In an article on past tense processing, Westermann and Ruh (2012) argue that "a dichotomy between regular and irregular verbs is a post hoc abstraction" (Westermann and Ruh 2012: 649). They refer to research by, among others, Joanisse and Seidenberg (2005) who have taken MRI scans of people processing regulars, irregulars and novel verbs, to discover patterns of activation during past-tense production.[16] Previous results of similar studies have shown that both novel and actual regular and irregular past tense verbs produce similar patterns of activation in one part of the brain (the posterior temporal lobe in both hemispheres). However, there was a greater degree of activation in a different part of the brain (the left and right inferior frontal gyrus) when producing regular past tense verbs, compared to irregular past tense production (Joanisse and Seidenberg 2005). These results have been considered by Pinker & Ullman (2002) to support the generativists approach to past tense production. Joanisse & Seidenberg argue against Pinker & Ullman, and claim that the "activation patterns were predicted by phonological characteristics of the past tense rather than by the rule-governed versus exception distinction that is central to the dual-mechanism framework" (Joanisse and Seidenberg 2005: 282).

6.2.1 MRI Screening by Joanisse & Seidenberg (2005)

Joanisse & Seidenberg (2005) divided past tense verbs into four categories based on the traditional regular/irregular divide, as well as on phonological similarity. They used 16 novel verbs, 16 regular verbs, 16 irregular verbs and 12 verbs labeled pseudoregulars. According to the researchers, there are two kinds of irregular verbs: those that are distinctively different from regular verbs, i.e. verbs that have past tense versions that are clearly different from the present tense form (e.g., "take/took" or "go/went"), and those verbs that are phonologically more similar to regulars (e.g., "sleep/slept" and "hear/heard"). The latter group of irregulars has been labeled pseudoregulars. Joanisse & Seidenberg (2005) argue that irregularity in pesudoregulars does not lie in the suffix, but in vowel change on the stem, also known as *ablauting*[17]. The regular *-ed* suffix has four allomorphs /t/, /d/, /ɪd/ and /əd/. Depending on whether the stem ends in a consonant, vowel or dental, regular past tense is realized as /t/, /d/, /ɪd, əd/, respectively. The suffixation rule for pesudoregulars is exactly the same. Table 15

[16] The participants were asked to generate the past tense form in their mind. To produce spoken past tense forms is not possible in an MRI machine because the effects of movement damage the images.
[17] Vowel change in verbs is known as *ablauting,* which is a kind of backing process. A front vowel in non-past moves to a more back vowel in past tense. For example /I/->æ/ in sing/sang or /I/ ->/ɔ/ in bring/brought (Jonge and Tobin 2011: 46)

shows the pseudoregulars used in Joanisse & Seidenberg's MRI study. Note that while there is vowel change in the stem (irregular), suffixation follows the regular pattern.

Table 15 Pseudoregular verbs used in Joanisse & Seidenberg's (2005: 296) study

Present tense form	Past tense form	Phonemic transcription of present tense form	Phonemic transcription of past tense form	
			Stem	Suffix
Leap	Lept	li:p	lɛp	t
Deal	Dealt	di:l	dɛl	t
Flee	Fled	fli:	flɛ	d
Sleep	Slept	sli:p	slɛp	t
Sell	Sold	sɛl	soʊl	d
Mean	Meant	(RP) mi:n (AE) mɪn [18]	mɛn	t
Lose	Lost	lu:z	lɒs	t
Feel	Felt	fi:l	fɛl	t
Hear	Heard	hɪə(r)	hɛ:	d
Tell	Told	tɛl	(RP) təʊl, (AE) toʊl	d
Think	Thought	θɪŋk	(RP) θɔ:, (AE) θɔ, θɑ	d
Say	Said	seɪ	sɛ	d

Joanisse and Seidenberg are critical of the claim that differences in brain activity associated with regular and irregular production supports the *Dual-Route* theory. They argue that such discoveries do not prove the existence of an innate rule. In their criticism of the *Dual-Route Model* they ask the two following questions:

[18]Phonetic transcription of Received Pronunciation (RP), a version of British English and American English (AE).

1. Is the regular versus irregular distinction sufficient to account for observed patterns of brain activity?
2. What kind of information underlies any observed difference between regular and irregular forms?

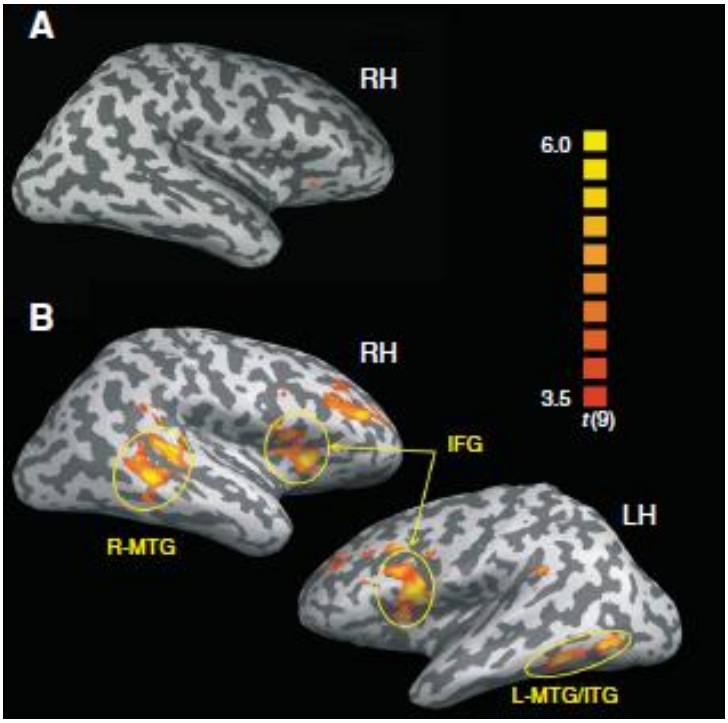
As Joanisse and Seidenberg (2005) introduce a third category, pseudoregulars, it is evident that their answer to the first question is that they do not consider the regular/irregular distinction to be sufficient. Rather, they consider past tense patterns on a "continuum ranging from highly consistent patterns (e.g., the standard present-past-tense transformation) to highly inconsistent patterns (e.g. suppletive verbs such as *go-went*); crucially, this account predicts intermediate cases exhibiting partial regularities" (Joanisse and Seidenberg 2005: 286).

Their answer to the second question is the source of their hypothesis. The underlying information determining whether verbs will show (on MRI) as regular or irregular is phonological and semantic information. Joanisse and Seidenberg (2005) argue that this can be tested by looking at neurological activation during the processing of pseudoregulars. If the activation is similar to the processing of irregulars, the *Dual-Route Model* is supported, since pesudoregulars will be produced as other irregulars (the default rule is blocked due to the retrieval of an irregular form by associative memory). However, if the patterns of activation during the production of pseudoregulars are similar to regular past tense processing, Joanisse and Seidenberg's *Single-Route* hypothesis is supported. They argue that this is likely as both regulars and pesudoregulars have a similar pattern of phonological suffixation (see Table 15).

When testing the two hypotheses, *Single* or *Dual-Route*, the researchers started by grouping regulars and novel verbs as one condition, and pseudoregulars and "true" irregulars as the second condition. They did not discover a significant cluster of activation with these conditions, which clearly shows that no brain region was more active when processing irregulars, compared to regular forms. However, they did identify a cluster of voxles in the right hemisphere (RH) inferior frontal gyrus (IFG). [19] Figure 5 shows activation levels in the right (RH) and left (LH) hemisphere of one of the participants during the MRI study. The cluster of voxels in the R-IFG reveals that there is greater activation in this area for combined regular and novel verbs than for the combined irregular verbs:

[19] "**Voxel (volume pixel)** abbreviation for volume element; a single cubic cell within a three-dimensional geometric solid grid or array" (Freitas 1999)

Figure 5 A cluster of significant voxels in right inferior frontal gyrus (R-IFG)

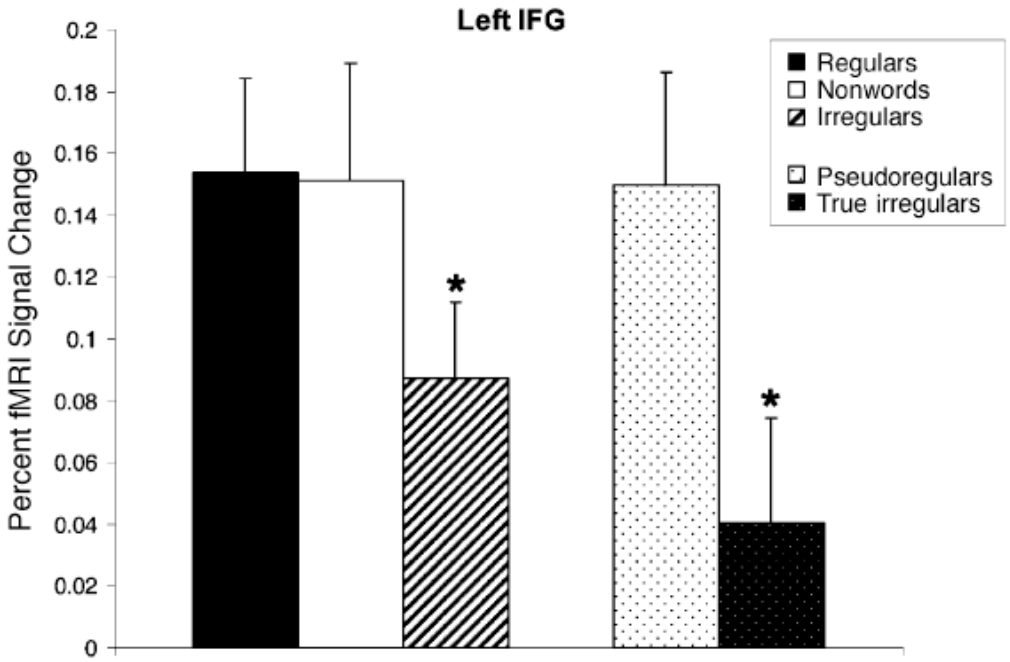


(Joanisse and Seidenberg 2005: 289)

That one cortical region (right inferior frontal gyrus) showed more activation for regulars than irregulars can be interpreted as support of the *Dual-Route Model*. However, this was only one of the analyses Joanisse and Seidenburg (2005) conducted. To be able to test whether or not there are areas in the brain specifically involved in processing of morphological rules, the researchers altered the conditions. They divided the second group of pseudoirregulars and true irregulars into two separate conditions. Now the results were inconsistent with the *Dual-Route Model* and showed that the true irregulars were different from regulars, while the pseudoregulars were not (Joanisse and Seidenberg 2005: 289).

Table 16 shows mean activation levels in the left inferior frontal gyrus when the participants were producing regulars, nonwords (novel words) and irregulars. In the two columns to the right, irregulars have been divided into pseudoregulars and true irregulars:

Table 16 Mean activation levels in the left IFG



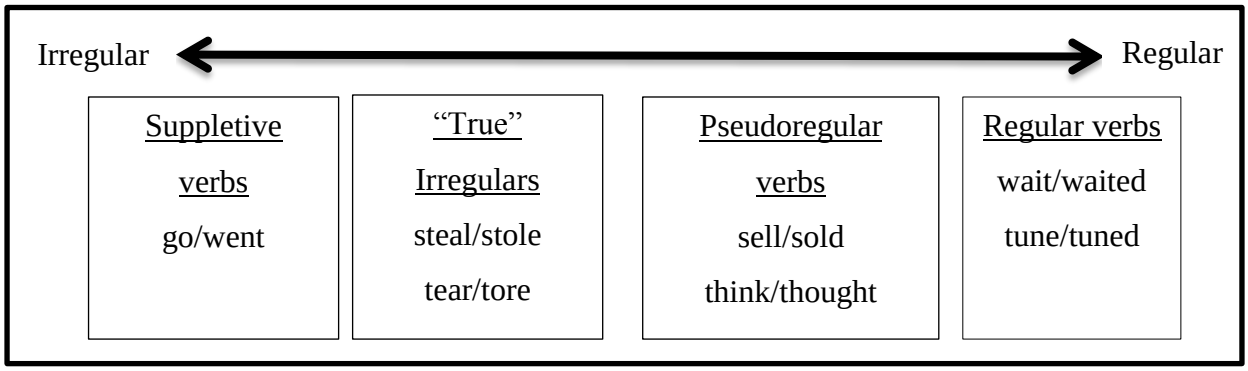
* Significantly different from regulars and nonwords, $p < .05$.

(Joanisse and Seidenberg 2005: 291)

The pseudoregulars (such as *sleep/slept* and *sell/sold*) are usually classified as irregular verbs. According to these results, however, they did not differ from either the regulars or the novel verbs (who usually receive regular inflection). Joanisse and Seidenberg (2005) consider this an argument against the claim that specific regions of the brain are involved in processing of morphological rules, as has been claimed by generativists (such as Ullman 2001). Rather, they argue that the "differences in signal levels for regulars and irregular in IFG in fact reflect a graded distinction between forms, […] these effects are likely due to factors related to phonological similarity rather than to the existence of a rule mechanism" (Joanisse and Seidenberg 2005: 290).

According to this study, one might argue that the MRI images show that the traditional regular-irregular dichotomy is false. When a third group of verbs (the pseudoregulars) is introduced, the distinction between regulars and irregulars becomes more complex. A better way to refer to verbs is along a scale from more (suppletives) to less (pseudoregulars) irregular on a scale based on phonological similarity. As illustrated in Figure 6, regular verbs would be considered at the opposite end of the scale of the archetypical irregular verbs:

Figure 6 Verbs illustrated on a continuum from irregular to regular



The regular-irregular dichotomy has been a premise for the past tense debate . The generativist, *Dual Route* approach, assumes a clear distinction between rule induction and rote learning. How can generativists argue of two separate mechanisms if past tense forms are presented along a scale? In section 7.6 I will discuss how the results of Joanisse and Seidenberg's (2005) study influence the debate between generativists and constructivists.

7. Discussion and Conclusion

In this chapter I will give a detailed comparison and evaluation of the studies presented on impaired and regular language acquisition. In chapters 4, 5 and 6 I have referred to ten studies on past tense production, trying to discover whether inflectional processes are best described using a generativist or constructivist approach. Table 7 summarizes the results from the studies discussed in relation to the theory they support:

Figure 7 Studies referred to in this thesis

	Studies on typical past tense acquisition argue in favor of the				
Constructivist account	McClelland & Patterson (2002)	Hoeffner (1996)	Marchman (1997)	Ramscar (2002)	
Generativist account	Marcus et al. (1992)	Marchman (1997) interpreted by Ambridge & Lieven (2011)			
	Studies on SLI show arguments in favor of the				
Constructivist account	Marchman (1999)	Serratrice et al. (2003)	Maillart & Schelstraete (2002)	Bishop et al. (2006)	Joanisse & Seidenberg (2005)
Generativist account	Ullman & Van der Lely (2001)				

The majority of the studies support the constructivist, *Single-Route* approach to explain the mechanisms involved in past tense production. However, to conclude that the generativist approach is incorrect might be impetuous. My selection of studies is not a representative sample of all studies on regular and language impaired past tense production. Neither is it always the case that the majority holds the key to one solution. Studies differ for example in terms of approach to the topic, methodology and theoretical background of researchers. This will, in my opinion, influence the outcomes of the research. In the following sections I will consider the results of the six studies on SLI (cf. section 5.2.1-4 and 6.1-2), and discuss how their results influence the debate between constructivists and generativists.

7.1 Influence of Phonological Neighbours

Out of the six studies on children with SLI, five support the constructivists, and argue that the *Single-Route Model* best describes past tense acquisition, while one support the generativist, *Dual-Route Model*. Marchman et al.'s (1999) main argument is that the same mechanisms cause regularization errors, irregularization errors and zero-marking errors. As their study showed that both regular and irregular verbs are prone to overgeneralization due to inter item similarity to phonological neighbours (cf. section 5.2.1.2), they argue that an innate rule mechanism (acting independently of influence by phonological neighbours) does not exist. Van der Lely and Ullman (2001) (cf. section 5.2.3) are critical to Marchman and colleagues' (1999) method. In their opinion, a better way of testing child language acquisition is to include past tense production of novel verbs. When including this group of verbs, the study revealed that regulars and irregulars were not influenced to a similar extent by phonological neighbours. The children showed a tendency to produce more regularization errors for real and novel irregular verbs than for real and novel regular verbs (cf. section 5.2.3.2). The higher number over regularization errors can be explained by the *Blocking and Retrieval Failure Hypothesis* by Marcus et al. (1992) (cf. section 4.1.3.1), when access to memorized forms fail, the regular suffix *–ed* is applied per default. Thus, if novel verbs are included when studying the effects of phonological neighbours, the *Dual-Route* approach to past tense acquisition is supported.

7.2 Extended Optional Infinitive Phase

Concerning SLI children's past tense production, Marchman and colleagues (1999) support Rice et al.'s (1995) theory of an *Extended Optional Infinitive Phase* (EOIP) (cf. section 3.3). Their study shows that SLI children have a higher number of zero-marking errors and appear to be more sensitive to phonological features in the stem. Their constructivist argument is that

over-sensitivity to phonological features interferes with efficient lexical processing and thus complicates the organization of inflectional patterns.

Generativists, Van der Lely and Ullman (2001) replicated Marchman et al's (1999) study (though including novel verbs), their results were similar, but they offered different explanations. When Van der Lely and Ullman (2001) saw that G-SLI children produced unmarked forms in past tense contexts, they argued for an impairment in the grammatical computations underlying the *–ed* suffixation rule. Both Generativists and constructivists are able to provide an explanation for the EOIP in children with SLI. Can both constructivist and generativists be right? Their respective positions for and against the existence of an innate rule system are not possible to unite, especially since innateness is not a matter of degrees. However, it is difficult to determine which approach is correct based on the two studies under consideration. Both constructivists (Marchman et al.) and generativists (Van der Lely and Ullman) found explanations for the results supporting their own theory. This makes it difficult to interpret which approach contributes with the most accurate description of processes underlying acquisition of inflectional morphology.

7.3 Overgeneralization Errors

The four remaining studies on SLI of the total six I have referred to, namely Serratrice et al. (2003), Maillart & Schelstraete (2002), Joanisse & Seidenberg (2005) and Bishop et al. (2006) support the constructivist approach. Serratrice et al. (2003) focus on what occurs at the onset of overgeneralization. Generativists argue that when overgeneralization errors occur, it marks a qualitative shift in the child's mental representation of finiteness and obligatoriness of tense marking. Serratrice et al.'s (2003) study showed no such increase, in neither SLI children nor TD children's use of finite forms in finite contexts. These findings are interpreted as an argument against the generativist approach. Serratrice et al. (2003) argue that there does not exist an across the board rule as overgeneralization did not lead to higher frequency of regular verbs in obligatory contexts.

In my opinion, the generativist argument explains why the qualitative shift does not appear to be prominent in Serratrice et al's (2003) study. Markus et al.'s (1992) *Blocking and Retrieval Failure Hypothesis* argues that when a child has acquired an irregular form, the acquired form will block the default rule (add *–ed*). This should eliminate regularization errors and mark a qualitative shift, similar to the shift in the child's mental representation of finiteness, argued above. However, Marcus et al. (1992) also argue that the overgeneralization rate will never be

0%, as a child's memory is not perfect. An overgeneralization rate that is systematically less than 50% supports the *Blocking and Retrieval Failure Hypothesis* according to Marcus et al. (1992) (cf. section 4.1.3.1). Such results might not be interpreted as the qualitative shift that Serratrice et al. (2003) were looking for. How low the rate of overgeneralization errors should be to support either the constructivist or generativist approach has not been established. Though Generativists argue that the rate should be low once a child has acquired the rule, Marcus et al. (1992) defend that outliers with a overgeneralization rate such as 47,6% and 23.1%, still support the *Blocking and Retrieval Failure Hypothesis*. Constructivists would disagree and argue that overgeneralization rates decline gradually because both the irregular form and the overregularizaed regular form may co-exist (cf. section 4.1.3.2). Both schools have valid arguments on why the overgeneralization rate may vary. However, as both theories are able to explain periods of higher rates (though the generativists argue that it should mainly be low), studies on overgeneralization rates are, in my opinion, not suited to distinguish which approach best describes past tense acquisition.

7.4 Working Memory Deficit

Maillart and Schelstraete (2002) argue that SLI is a result of impaired Working Memory (cf. section 5.2.4.1). Their study showed that overload on working memory, influence SLI children's performance on linguistic tasks to a larger extent, compared to language and age-matched controls. This result supports the constructivist approach as it shows that SLI is not an entirely grammatical impairment. It opposes the generativist hypothesis that the deficit has a grammatical origin, such as Rice and Wexler's (1995) *Extended Optional Infinitive Account*, or Van der Lely's (1998) *Representational Deficit for Dependent Relationships* theory. Based on their results, Maillart and Schelstraete (2002) argue that grammatical performance in children with SLI depend more on the load composed in working memory than on actual grammatical abilities.

7.5 Genetic Influence

Bishop and colleagues (2006) considered genetic influence on SLI. They discovered two phenotypic markers of heritable language impairment. First, an impaired capacity of carrying out grammatical computations, and secondly, impaired Short-Term Memory. As the two phenotypic markers did not overlap in the twin population, the researchers concluded that there is not a singular cause of SLI, but several. Thus they are critical of the claim that SLI may be explained as a grammar specific deficit. Even though the study did not discover an overlap between these two phenotypic markers, there may be a third overarching cause of SLI

which has not yet been discovered. Bishop et al.'s (2006) conclusion encourages further research on genetic influence on language deficits.

7.6 Outdated Dichotomy?

Joanisse and Seidenberg (2005) conducted MRI scans of people processing regular and irregular past tense verbs. They argue that no specific brain region is involved in the processing of morphological rules, whence an innate area processing morphological rules does not exist. A central argument in their study is that the regular/irregular dichotomy is outdated. They argue that some irregulars may be more similar to regulars in terms of past tense inflection. Joanisse and Seidenberg (2005) label these verbs "pseudoregulars" and show how some verbs are neither entirely regular, nor entirely irregular. This is an interesting contribution to the discussion of whether regulars and irregulars are produced in one (similar) or two (different) mechanisms. Joanisse and Seidenberg (2005) argue that their "results support the theory that the key building block of language are sound and meaning, rather than words and rules" (Joanisse and Seidenberg 2005: 294). In other words, they argue for a constructivist approach to language acquisition.

Could their results be interpreted as support for the generativist approach as well? Joanisse & Seidenberg (2005) argue that the suffixation pattern for regulars and pseudoregulars is the same (cf. section 6.2.1). The MRI signals registered during the production of verbs labeled "true irregulars" were different compared to the signals registered during production of pseudoregulars and regulars. Could the signals registered for regulars and pseudoregulars reveal the area of an innate rule mechanism? The irregularity of pseudoeregulars does not lie in the suffix, but in vowel change on the stem. Thus, Joanisse and Seidenberg's (2005) results show that past tense verbs with regular suffixation are produced in a different part of the brain than irregular past tense verbs. From a generativist point of view, this data supports the existence of an innate area of rule production

7.7 Concluding remarks

Five of six studies I have referred to on SLI, support the constructivist approach to language acquisition. However, SLI data from Ullman and Van der Lely's (2001) study showed that it is possible to argue for the generativist account as well. The studies revealed that children with SLI are not a homogenous group. Children who suffer from Grammatical-SLI (cf. section 5.2.3.1) may not have the same impairment as children with impaired working memory (cf. section 5.2.4.1). This is an important distinction because studies of children with

impaired working memory may not reveal much about impaired grammatical ability. Looking at the studies I have referred to, only one tested children with G-SLI. This was Ullman and Van der Lely (2001) who argued that G-SLI children have an impairment in the grammatical computations underlying the *–ed* suffixation rule. An argument based on data showing that G-SLI children overregularize less than TD controls. In my opinion this argument from studies on G-SLI children may reveal more about impaired morphological processing, than the five studies on SLI children in general.

In conclusion the aim of my study was to discover whether data on SLI supports the generativist or constructivist approach to past tense acquisition. I discovered that SLI is a complex disorder with different causes and manifestation. Thus it is important to include a grammatically impaired subgroup of SLI children, known as G-SLI children, when testing production of inflectional morphology. The results of the studies referred to in this thesis revealed that data on SLI children in general supports the constructivist approach. While data on a G-SLI children supports the generativist approach.

8. References

Allen, S. (2009). Verb argument structure. The Cambridge handbook of child language. E. L. Bavin. Cambridge, Cambridge University Press**:** X, 596 s. : ill.

Ambridge, B. and E. V. M. Lieven (2011). Child language acquisition. Cambridge, Cambridge University Press.

Baddeley, A., et al. (1998). "The phonological loop as a language learning device." Psychological review **105**(1): 158.

Baddeley, A. D. (2007). Working memory, thought, and action. Oxford, Oxford University Press.

Bates, E., et al. (1995). Individual Differences and their Implications for Theories of Language Development. The Handbook of child language. P. Fletcher and B. MacWhinney. Oxford, Blackwell.

Behrens, H. (2009). Grammatical Categories. The Cambridge handbook of child language. E. L. Bavin. Cambridge, Cambridge University Press**:** X, 596 s. : ill.

Berko, J. (1958). The child's learning of English morphology, Radcliffe College**:** 150-177.

Bishop, D. V., et al. (2006). "Distinct genetic influences on grammar and phonological short-term memory deficits: evidence from 6-year-old twins." Genes, Brain and Behavior **5**(2): 158-169.

Bishop, D. V., et al. (1995). "Genetic basis of specific language impairment: Evidence from a twin study." Developmental Medicine & Child Neurology **37**(1): 56-71.

Bishop, D. V. M. (1997). Uncommon understanding. Hove, Psychology Press.

Brown, R. (1973). A first language: The early stages, Harvard U. Press.

Bybee, J. L. and D. I. Slobin (1982). "Rules and schemas in the development and use of the English past tense." Language: 265-289.

Cazden, C. B. (1968). "The acquisition of noun and verb inflections." Child development: 433-448.

Chomsky, N. (1957). Syntactic structures. Oxford, England, Mouton.

Freitas, R. A. (1999). Nanomedicine, Volume I, Basic capabilities. Austin, TX, Landes Bioscience.

Gathercole, S. E. and A. D. Baddeley (1990). "Phonological memory deficits in language disordered children: Is there a causal connection?" Journal of Memory and Language **29**(3): 336-360.

Gathercole, S. E., et al. (1994). "The children's test of nonword repetition: A test of phonological working memory." Memory **2**(2): 103-127.

Gleason, J. B. and N. B. Ratner (2009). The development of language. Boston, Pearson.

Gleitman, L. R. and H. Gleitman (1992). "A picture is worth a thousand words, but that's the problem: The role of syntax in vocabulary acquisition." Current Directions in Psychological Science **1**(1): 31-35.

Haynes, C. (1982). "Vocabulary acquisition problems in language disordered children." Unpublished M. Sc. thesis, Guy's Hospital Medical School, University of London. Cited in J. Harris and M. Coltheart (1986) Language Processing in Children and Adults: An Introduction. London: Routledge and Kegan Paul.

Hoeffner, J. (1996). "A single mechanism account of the acquisition and processing of regular and irregular inflectional morphology." Unpublished doctoral dissertation, Department of Psychology, Carnegie Mellon University, Pittsburgh, PA.[JLM].

Joanisse, M. F. and M. S. Seidenberg (2005). "Imaging the past: Neural activation in frontal and temporal regions during regular and irregular past-tense processing." Cognitive, Affective, & Behavioral Neuroscience **5**(3): 282-296.

Jonge, B. d. and Y. Tobin (2011). Linguistic theory and empirical evidence. Amsterdam, John Benjamins Pub. Co.

Leonard, L. B. (1998). Children with specific language impairment. Cambridge, Mass., MIT Press.
Leonard, L. B. (2009). Language symptoms and their possible sources in SLI. The Cambridge handbook of child language. E. L. Bavin. Camebridge, Cambridge University Press**:** X, 596 s. : ill.
Leonard, L. B. and R. G. Schwartz (1985). "Early linguistic development of children with specific language impairment." Children's language **5**: 291-318.
Lewis, B. A. and L. A. Thompson (1992). "A study of developmental speech and language disorders in twins." Journal of Speech & Hearing Research.
Lightfoot, D. (2006). How new languages emerge, Cambridge University Press.
MacWhinney, B. (2000). The CHILDES Project: Tools for analyzing talk. transcription format and programs, Routledge.
Maillart, C. and M.-A. Schelstraete (2002). "Morphosyntactic Problems in Children with Specific Language Impairment: Grammatical SLI or Overload in Working Memory?" Investigations in clinical phonetics and linguistics: 85-97.
Maratsos, M. (2000). "More overregularizations after all: new data and discussion on Marcus, Pinker, Ullman, Hollander, Rosen & Xu." Journal of Child Language **27**(1): 183-212.
Marchman, V. A. (1997). "Children's productivity in the English past tense: The role of frequency, phonology, and neighborhood structure." Cognitive Science **21**(3): 283-303.
Marchman , V. A., et al. (1997). "Overregularization in English plural and past tense inflectional morphology : a response to Marcus (1995)." Journal of Child Language **24**(3): 767.
Marchman, V. A., et al. (1999). "Morphological productivity in children with normal language and SLI: A study of the English past tense." Journal of Speech, Language and Hearing Research **42**(1): 206.
Marcus, G. F., et al. (1992). "Overregularization in language acquisition." Monographs of the Society for research in child development: i-178.
Maslen, R. J., et al. (2004). "A dense corpus study of past tense and plural overregularization in English." Journal of Speech, Language and Hearing Research **47**(6): 1319.
McClelland, J. L. and K. Patterson (2002). "Rules or connections in past-tense inflections: What does the evidence rule out?" Trends in Cognitive Sciences **6**(11): 465-472.
McClelland, J. L. and K. Patterson (2002). "'Words< i> or</i> Rules' cannot exploit the regularity in exceptions." Trends in Cognitive Sciences **6**(11): 464-465.
McClelland, J. L. and D. E. Rumelhart (1986). Parallel distributed processing: explorations in the microstructure of cognition. Cambridge, Mass., MIT Press.
Oliver, B., et al. (2004). "Verbal and nonverbal predictors of early language problems: An analysis of twins in early childhood back to infancy." Journal of Child Language **31**(3): 609-631.
Pinker, S. (1991). "Rules of language." Science **253**(5019): 530-535.
Pinker, S. (1999). Words and rules: the ingredients of language. London, Weidenfeld & Nicolson.
Pinker, S. and A. Prince (1988). "On language and connectionism: Analysis of a parallel distributed processing model of language acquisition." Cognition **28**(1): 73-193.
Pinker, S. and M. T. Ullman (2002). "The past and future of the past tense." Trends in Cognitive Sciences **6**(11): 456-463.
Radford, A. (2004). Minimalist syntax: Exploring the structure of English, Cambridge University Press.
Ramscar, M. (2002). "The role of meaning in inflection: Why the past tense does not require a rule." Cognitive Psychology **45**(1): 45-94.

Ramscar, M. and D. Yarlett (2007). "Linguistic Self-Correction in the Absence of Feedback: A New Approach to the Logical Problem of Language Acquisition." Cognitive Science **31**(6): 927-960.
Rice, M. and K. Wexler (2001). "Test of early grammatical impairment." Psychological Corporation.
Rice, M. L. and K. Wexler (1996). "Toward tense as a clinical marker of specific language impairment in English-speaking children." Journal of Speech, Language and Hearing Research **39**(6): 1239.
Rice, M. L., et al. (1995). "Specific language impairment as a period of extended optional infinitive." Journal of Speech, Language and Hearing Research **38**(4): 850.
Rice, M. L., et al. (1998). "Tense over time: The longitudinal course of tense acquisition in children with specific language impairment." Journal of Speech, Language and Hearing Research **41**(6): 1412.
Rice, M. L., et al. (2000). "Acquisition of irregular past tense by children with specific language impairment." Journal of Speech, Language and Hearing Research **43**(5): 1126.
Rumelhart, D. E. and J. L. McClelland (1986). Parallel distributed processing: explorations in the microstructure of cognition. Cambridge, Mass., MIT Press.
Semel, E. M., et al. (1987). CELF-R: Clinical Evaluation of Language Fundamentals--Revised, Psychological Corporation, Harcourt Brace Jovanovich.
Serratrice, L., et al. (2003). "The acquisition of past tense in preschool children with specific language impairment and unaffected controls: Regular and irregular forms." Linguistics **41**(2; ISSU 384): 321-350.
Tomblin, J. B. (2009). Children with specific language impairment. The Cambridge handbook of child language. E. L. Bavin. Camebridge, Cambridge University Press.
Tomblin, J. B. and P. R. Buckwalter (1998). "Heritability of poor language achievement among twins." Journal of Speech, Language and Hearing Research **41**(1): 188.
Tomblin, J. B., et al. (1997). "Prevalence of specific language impairment in kindergarten children." Journal of Speech, Language and Hearing Research **40**(6): 1245.
Ullman, M. T. (2001). "A neurocognitive perspective on language: The declarative/procedural model." Nature reviews neuroscience **2**(10): 717-726.
Valian, V. (2009). Innateness and Learnability. The Cambridge handbook of child language. E. L. Bavin. Cambridge, Cambridge University Press**:** X, 596 s. : ill.
Van der Lely, H. K. (1998). "SLI in children: Movement, economy, and deficits in the computational-syntactic system." Language Acquisition **7**(2-4): 161-192.
Van der Lely, H. K., et al. (2004). "Grammatical language impairment and the specificity of cognitive domains: relations between auditory and language abilities." Cognition **94**(2): 167-183.
Van der Lely, H. K. and M. T. Ullman (2001). "Past tense morphology in specifically language impaired and normally developing children." Language and Cognitive Processes **16**(2-3): 177-217.
Wechsler, D. (1999). Wechsler abbreviated scale of intelligence, Psychological Corporation.
Westermann, G. and N. Ruh (2012). "A neuroconstructivist model of past tense development and processing."
Wexler, K. (1998). "Very early parameter setting and the unique checking constraint: A new explanation of the optional infinitive stage." Lingua **106**(1): 23-79.

Online references

OED. ""allele, n."." Oxford English Dictionary. from http://www.oed.com/view/Entry/5236?redirectedFrom=allele.
OED. ""drosophila, n."." Oxford English Dictionary. from http://www.oed.com/view/Entry/57917?rskey=kRWtMh&result=5&isAdvanced=false.
OED. ""lie, v.1"." Oxford English Dictionary. from http://www.oed.com/view/Entry/108041?rskey=zUkOXN&result=6&isAdvanced=false.
OED. ""lie, v.2"." Oxford English Dictionary. from http://www.oed.com/view/Entry/108042?rskey=zUkOXN&result=7&isAdvanced=false.
OED. ""phenotype, n."." Oxford English Dictionary. from http://www.oed.com/view/Entry/142359?rskey=SZmSig&result=1&isAdvanced=false.