Testing the Extended Optional Infinitive Hypothesis in English and German

Thesis submitted in accordance with the requirements of the University of Liverpool for the degree of Doctor in Philosophy

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March 2020

Acknowledgements

I want to express my thanks to my supervisors Ben Ambridge, Elena Lieven and Julian Pine for their excellent guidance and patience. I also want to thank all the other members of our research group, and the Psychology department from the University of Liverpool and its people. Furthermore, I want to thank LuCiD project were my PhD was part of, with its amazing opportunities for young researchers to gain knowledge from scientists and grow in a productive environment.

I would like to thank my supervisors for their support. It was an honour to work with you. Especially Julian Pine for many many hours of discussing the theories behind these studies. For all your feedback that helped me to develop and bring this PhD further.

This research was made possible by a grant awarded to Charleen List by the Economic and Social Research Council (ES ⁄ L008955 ⁄ 1), as part of a studentship from the ESRC International Centre for Language and Communicative Development (LuCiD).

Thanks to Maria and Claire for coding and rating to provide an inter-rater reliability.

I would like to thank all parents, nurseries and schools, who have agreed to take part and especially the children who joined these studies and took part in the experiments.

A big *Thank You* goes to Dagmar Bittner and Peter Jordens who have always been helpful and supported me in my academic career since 2012. Especially, I would like to thank Dagmar Bittner for giving me access to the Bastian Corpus.

Thanks to my beloved colleagues from my office 2.80 in the ERB, which were always a great support. I'm so glad I met you all! Especially, I want to thank Lana for her help and advice in all PhD related and unrelated situations.

I thank my parents, without whom it would never have been possible to even think about a PhD. And thanks to the rest of the family who cheered and supported me in the background.

I'm very thankful for my husband Martin, who went on this journey with me and even moved to a different country with me to make my dream come true.
I love you.

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Abstract

In the field of child language acquisition, children's acquisition of verb inflection and the production of errors during this process has long been discussed in terms of two contrasting approaches: the generativist approach and the constructivist approach. The generativist approach (Chomsky, 1957; 1965; Guasti, 2004; Hyams, 1986; Radford, 2004, Wexler, 1994; 1998) is characterised by the view that grammar is a set of categorical rules and constraints that are specified innately or acquired on the basis of a limited number of cues in the input language (e.g., via parameter setting).

A well-established theory on the acquisition of verb marking in typically developing (TD) children is the Optional Infinitive (OI) Hypothesis (Wexler, 1994). According to this hypothesis children's verb-marking errors reflect a stage in which their grammars allow non-finite forms (e.g. `paint') in contexts in which finite forms (e.g. `paints') are required. By postulating an (Extended) Optional Infinitive ((E)OI) Stage (Wexler, 1994; Rice, Wexler & Cleave, 1995) the assumptions of this account have been broadened to include the group of children with Developmental Language Disorder (DLD). These children are assumed to produce OI errors at higher rates than both age-matched and language-matched controls even at relatively high MLUs.

The constructivist view, on the other hand, argues that children's early grammar develops by learning and then generalising over specific instances in the input, and emphasises the distributional patterning of the input language (e.g., Bybee, 1995; 2010; Ambridge & Lieven, 2011; Tomasello, 2000a; 2003).

In this thesis, the Dual-Factor Model (Freudenthal, Pine & Gobet, 2010; Freudenthal, Pine, Jones & Gobet, 2015a) represents this kind of input driven account. According to the Dual-Factor Model (Freudenthal, et al., 2010, 2015a), children's verb-marking errors reflect the learning of infinitives from compound finite structures in the input (which, in German, take the form `He can a house build-INF'). Children produce infinitives in compound-finite contexts because they are effectively truncated modals. However, TD children and children with DLD (to a greater extent) also tend to default to familiar forms, which means that they also tend to produce those verb forms that occur with particularly high frequency in the target language in inappropriate contexts.

The following dissertation aims to test these two different models of the pattern of verb-marking error in English- and German-speaking children with DLD and language-matched controls. Chapter 1 provides a brief introduction to the thesis. In chapter 2 the theoretical assumptions of each account are presented. Chapter 3 focusses on the specific group of children with DLD and describes the research questions of the thesis, that will be answered with the help of the studies in chapters 4 to 6.

To test the predictions of the two models, two verb elicitation experiments were conducted one on English-speaking children with DLD and language-matched controls (chapter 4) and one on German-speaking children with DLD and language-matched controls (chapter 6). These experiments involved eliciting a range of verbs which occurred in two different conditions: a simple-finite condition (e.g. ‘Lisa paints a flower. Peter ... ’) and a compound-finite condition (e.g. ‘Peter can a car paint-INF. Lisa … ’). The EOI hypothesis predicts an EOI stage in both English- and German-speaking children with DLD and no effect of condition or relative input frequency, whereas the Dual-Factor predicts an EOI stage in English and an effect of condition in German, and effects of relative input frequency in both languages. The results are broadly consistent with the prediction of the Dual-Factor Model. However, they only show an input effect in English-speaking children, and this effect is only significant in the DLD group.

Chapter 5 reports a German study in which a child with DLD is compared with a language-matched control child. The results of this study were also broadly consistent with the Dual-Factor Model, but in this case also revealed semantic conditioning and relative frequency effects in both children.

Finally, Chapter 7 concludes the thesis by summarizing the findings of the three empirical studies, and discussing the main implications of the results for the EOI hypothesis and the Dual-Factor Model of OI errors. This chapter ends by suggesting some possible directions for future research.

Rationale for submitting the thesis in an alternative format

This thesis has been prepared following the *alternative paper format*, in accordance with the guidelines provided by the University of Liverpool for including research papers in a doctoral thesis. This alternative format was selected for the purpose of facilitating the publication of this research in scientific journals. Specifically, chapters 4 and 6 represent separate manuscripts and are structured in a manner suitable for submission to a peer-reviewed journal. At the time of writing, chapter 5 has been accepted by the editors Peter Jordens and Dagmar Bittner to be published in the book “Driving Forces in Language Development”, whereas chapter 4 and 6 are in preparation to be submitted to peer-reviewed journals.

For consistency, the formatting of these papers matches the common font and style used throughout the thesis. No reference section is provided after each paper, with all citations presented in a single bibliography at the end of the thesis. For continuity, neither the experiment numbers nor figure indices reset between the chapters. Otherwise, the chapters are presented in the same format as the manuscripts that would be submitted for publication, with an additional summary at the outset to explain how the papers fit within the broader narrative of the thesis. This means that each chapter starts with a review of the relevant literature to introduce an informed reader to the topic and ends with a discussion of the implications of the results.

The thesis begins with some general introductory chapters that review the background of the research (Chapter 1 to 3) and concludes with a general discussion that summarises and discusses the overall outcomes of the research and how they fit into the wider context (Chapter 7). The main components of this dissertation are three research chapters that correspond to a corpus study and two experimental studies, all of them in publishable or published paper format.

The supervisors for my Ph.D. program, Prof. Julian M. Pine, Dr. Ben Ambridge and Prof. Elena Lieven, have provided helpful advice and instruction on all phases of research as well as on the current dissertation. Because all the published papers are co-authored with them, it is worth specifying that my own contribution to the papers is as follows. In addition to researching the literature and the research questions for each experimental paper, I have been responsible for the design of the studies including procedure and materials (pictures, audios, etc.), recruiting, testing participants, coding and analysing the data, writing the papers, and corresponding with the editors regarding revisions. Together, with my supervisors we discussed the design of the studies and how to interpret the data. They provided guidance throughout the processes of planning and writing this thesis.

CHAPTER 1: General Introduction

1.1 Introduction to the thesis

This doctoral dissertation presents three studies of language acquisition in English- and German-speaking children that test two theoretical models of how young children learn the pattern of verb marking in their language, and how this process goes wrong in children with Developmental Language Disorder (DLD). These questions are fundamental to our understanding of language acquisition.

It is first important to specify the theoretical framework adopted throughout the thesis. There are two competing approaches: the nativist/generativist and constructivist/usage-based approach. According to the nativist approach, the process of language acquisition can be explained by innate universal principles rather than by environmental factors that vary across individuals, languages and socio-cultural contexts (Guasti, 2004; Hyams, 1986). The terms nativist and generativist will be used in this thesis interchangeably to refer to this kind of approach.

Since the 1950s, nativist accounts have dominated the field of language acquisition, especially with the work of Chomsky (1957; 1981; 1993; 2014). According to these accounts, children have abstract knowledge of grammar (Universal Grammar) from the start of the process. On the one hand, there are innate syntactic components including principles and parameters, rules (operations), and word classes and phrasal categories that guide children through the language acquisition process. On the other hand, children expand their lexicons by learning words and morphemes from their input. Words are language-specific conventions and are learned and stored in memory. Nativist theories assume that language structures (syntax) emerge by setting parameters on the basis of a minimal amount of input. Children's task is to map the language they hear onto their innate universal grammar.

The constructivist approach, in contrast, assumes that no innate linguistic knowledge is required in order to acquire a language, but that acquisition occurs via generalized, domain-general learning mechanisms (e.g., Tomasello, 2000a; 2000b). In this thesis, the terms constructivist and usage-based will be used interchangeably to refer to this approach.

Constructivist accounts view language as a collection of linguistic constructions serving communicative functions. They do not draw such a clear distinction between the grammar and the lexicon. Language is used in social communication and expands through experience and social exchange. Children acquire language by learning chunks of language from the input, and storing, abstracting and generalizing across them. The child analyses the input from the environment and knowledge of the language is constructed as a result of this analysis.

To conclude, generativist and constructivist accounts reflect fundamentally different approaches towards language and offer different kinds of explanations and predictions about different aspects of children's language. Researchers have investigated different linguistic phenomena to answer the question of whether or not language is innate. With the help of naturalistic and experimental studies of children learning different languages, they have developed theories and models to answer this question. This cross-linguistic dimension is important because young children are able to learn any of the languages of the world to which they are exposed. Models of the language acquisition process must therefore be able to explain the acquisition data from any of the world's languages.

The acquisition of verb morphology is an interesting topic for both kinds of theoretical approach, and has already been the subject of a great deal of cross-linguistic research in the field. Over the years, nativist and constructivist theories have proposed several different explanations of how children come to acquire the pattern of verb marking in their language. Nativist accounts have based their explanations on innate knowledge, constructivist accounts on input-driven learning mechanisms.

This thesis will focus on the acquisition of inflectional verb morphology in English and German. Two models, one representing each theoretical approach, will be analysed and their theoretical predictions will be compared with the results from three studies of children's use of inflectional verb morphology. One model of this process, which has been particularly influential in the DLD literature, is the (Extended) Optional Infinitive ((E)OI) Hypothesis (Wexler, 1994; Rice, et al., 1995)), which assumes that the pattern of verb marking error in young children's speech reflects a maturationally controlled difference between the child and the adult grammar. In contrast, stands the Dual-Factor Model (Freudenthal, et al., 2010; 2015a), which assumes that children's verb-marking errors reflect two processes: the learning of bare infinitives (or Optional Infinitive errors) from compound-finite structures in the input and a process of defaulting to the most frequent form of the verb.

These two models have very different implications both for theory building and for the design of effective interventions for children with DLD. Therefore, it is important to establish which one provides the best fit to the data. However, distinguishing between them empirically requires cross-linguistic research on both typically developing children and children with DLD. Previous results of cross-linguistic studies of DLD (particularly of DLD in German) have been somewhat equivocal (Rice, Noll & Grimm,1997; Roberts & Leonard, 1997). This study will therefore compare different accounts of the pattern of verb-marking error in typically developing children and children with DLD in English and German.

1.2 The structure of the thesis

The structure of the rest of the thesis is as follows. Chapter 2 presents an introduction to the acquisition of inflectional morphology. It also provides a brief description of the system of inflectional verb morphology in English and German and how it interacts with the word order rules of each language. The chapter then goes on to explain the basic assumptions about how children learn inflectional verb morphology according to nativist/generativist and constructivist/usage-based theories; describes the Optional Infinitive (OI) phenomenon and describes how OI errors are explained by different nativist and constructivist theories.

Chapter 3 introduces DLD and provides a general overview of the symptoms and clinical markers of DLD, and how these present in English and German. This chapter also focusses on the specific difficulties children with DLD have with the acquisition of inflectional verb morphology.

Furthermore, it presents an overview of the relevant theories and the research questions that are addressed in the thesis. It also presents a description of the methods used in the studies that follow.

Chapter 4 reports an experimental study of the pattern of verb-marking error in a group of English-speaking children with DLD and a group of language-matched controls. This study was designed to investigate children's production of OI errors in two different conditions: a modal and a non-modal condition. Previous studies (Räsänen, Ambridge & Pine, 2014; Kueser, Leonard & Deevy, 2018) have shown that English-speaking children's tendency to produce OI errors on particular verbs in non-modal contexts is predicted by the relative frequency with which those verbs occur as bare stems versus 3sg present tense forms in English child-directed speech. The elicited production experiment reported here builds on these findings by adding a modal condition and testing the predictions of two different theoretical accounts with respect to the pattern of performance shown by the two groups of children.

Chapters 5 investigates the acquisition of verb inflection using a rich set of naturalistic speech data from a German-speaking child with DLD and a language-matched control child. The first part of this study addresses the question of whether the child with DLD produces higher rates of OI errors compared to a younger language-matched control, while the second and the third parts of the study explore the rate of verb positioning errors and agreement errors in the two children's speech. The final part of the study focusses on the relation between the by-verb rate of OI errors and the by-verb rate of infinitive versus finite forms in both children's input.

Chapter 6 reports an experimental study of the pattern of verb-marking error in a group of German-speaking children with DLD and a group of language-matched controls. This study builds on both the experimental study of English-speaking children (by extending it to German-speaking children) and on the corpus study of German (by extending the analysis to data collected in an experimental setting). As in the experimental study of English, the key aim of this study was to test the predictions of two different theoretical accounts of the verb-marking deficit in DLD: one of which predicts the same pattern of effects in English and German, and one of which predicts a different pattern of effects.

Chapter 7 provides a general discussion of the findings of the thesis. The findings from the individual studies are summarised and interpreted in the light of the literature from the two contrasting theoretical approaches. The chapter concludes by suggesting further studies that are necessary to gain a more complete understanding of the OI phenomenon and of the verb-marking deficit in children with DLD.

CHAPTER 2: The Acquisition of Inflectional Verb Morphology

2.1 Inflectional verb morphology

Using morphology productively means going beyond the process of single word learning to acquire the principles of complex word formation. Morphology refers to the study of words, their internal structure and how they are formed (e.g., Aronoff, & Fudeman, 2011). A word is a complex piece of information, and morphology deals with the systematic pairing of form and meaning at the word level (Booij, 2010: 3).

While some words are single units and cannot be further analysed (e.g., play), other words consist of sub-parts (e.g., play-ing, re-play), each of which is a different morpheme. A morpheme is the smallest linguistic unit that has a meaning or grammatical function. For example, the word replay can be segmented into two morphemes, re- and play, which have separate meanings. The traditional concern of morphology is the identification of the “shape” of morphemes, as well as their individual meanings under the assumption that any single morpheme has its own meaning and function (Bybee, 1985), although a one-to-one mapping of form and meaning or function is not always available (c.f., Aronoff 1976; Booij, 2010; Bybee, 1985; Hay & Baayen, 2005). Depending on the function the morphemes perform inside the word, they are given different names. The lexical meaning (e.g., play in replay) is carried by the root, which is the irreducible part of a word (primitive form). The other part of the word to which affixes are attached (e.g., kick in kicked) is the stem. It can be defined as the overlapping part of a word across different inflected forms. Root and stem can therefore be either the same or different (e.g., for home-less-ly, the root is home and the stem can be analysed as either home or homeless). Affixes are parts of words that attach to the stem such as –less (derivational affix) and –ly (inflectional affix for an adverb). There are several linguistic processes in morphology that create a new word. These are affixation, vowel change, compounding, and fusion. Affixation is a process of attaching affixes to word stems. Depending on the position to which it is attached, an affix is termed a suffix (attached to the end, like the -less in home-less), a prefix (attached to the head, like the un- in un-clear), an infix (inserted in the middle), and a circumfix (attached to both the head and the end). Vowel change is a process by which a change in the meaning or function of a word involves a vowel change (e.g., swim > swam). Compounding is the combination of self-standing items, as in bath-tub. Fusion is when two morphemes are fused together and not clearly separable (e.g., wanna = want to). Whereas compounding creates a new lexical entry, affixation, vowel change and fusion create a syntactic version of the same stem with different syntactic properties.

In this thesis, we are primarily concerned with inflectional verb morphology. Inflectional morphology refers to the “changes” that are made to words to express certain grammatical features and applies to nouns (e.g., the distinction between singular and plural) and verbs (e.g., the distinction between present and past). Other features that can be encoded by inflections depend on the language, and can include features such as gender, aspect, mood and definiteness (Slobin, 1982). Inflectional verb morphology can show substantial variation across languages, involving categories such as tense, person, number, mood, aspect, and polarity, depending on the language. The focus of this thesis will be on the acquisition of inflectional verb morphology and why verb inflections are sometimes missing or used incorrectly in children's speech. The languages under investigation are English and German, where verb inflection encodes tense and agreement (person and number). In the following sections, we therefore describe the system of inflectional verb morphology in English and German and the way that it interacts with the word order rules of each language.

2.1.2 Inflectional morphology in English

English is a West Germanic language of the Indo-European language family that is closely related to German and Dutch. As such, it shares many similarities with German. However, modern English has more impoverished inflectional morphology than German, with very limited gender and case-marking and relatively little inflectional verb morphology.

2.1.2.1 Inflectional verb morphology in English

In English, verbs are marked for tense, aspect and mood, and for subject-verb agreement (person and number), though in this thesis, we will be concerned primarily with tense and agreement marking. As regards tense marking, English distinguishes between past, present and future tense. Past tense is marked with the past tense morpheme -ed, present tense is unmarked or marked with the 3sg present tense morpheme -s, and future tense is expressed using the compound structure 'will + verb' (e.g. 'She will play tomorrow'). As regards agreement marking, English distinguishes between two different numbers (singular and plural) and three different persons: first person (the person or people speaking), second person (the person or people being addressed) and third person (a person or group of people who are neither the speaker nor the addressee). However, person and number are not distinguished in the past and future tense, and, in the present tense, only the third person singular is distinguished from the other person and number combinations by the addition of the third person singular present tense morpheme -s (e.g., ‘She play-s’ vs ‘I/We/You/They play’).

Differences in mood are expressed primarily through the use of modal verbs, which are marked for tense but not agreement, and combine with the infinitive, which is indistinguishable from the bare form of the verb (e.g. present tense: ‘She can play’; past tense: ‘She could play’). Differences in aspect are marked through the use of perfect (-ed) and progressive (-ing) morphemes which combine with the verb to form perfect and progressive participles. These participles combine with the auxiliary verbs ‘have’ and ‘be’, which are marked for both tense and agreement (e.g. perfect: ‘She has/had walked’; progressive ‘She is/was walking’).

In terms of word order, English is a predominantly SVO language - though with some vestiges of V2 (Westergaard, 2007). This means that lexical verbs tend to occur after their subjects and before their complements regardless of whether they are finite or non-finite (e.g. finite: ‘She kicks the ball’; non-finite: ‘She can kick the ball’). Modern English does not allow subject main-verb inversion (e.g. ‘*What plays she?’). Instead, questions are formed through subject auxiliary inversion (e.g. ‘What is she playing?). This process requires the insertion of the dummy auxiliary ‘do’ in questions where the corresponding declarative sentence does not include an auxiliary verb (e.g. ‘She plays football’ -> ‘What does she play?’), with the result that auxiliary + verb structures are particularly frequent in English, since the vast majority of questions include some kind of auxiliary verb.

2.1.3 Inflectional morphology in German

Like English, German is a West Germanic language of the Indo-European language family that is closely related to Dutch. As such, it shares many similarities with English. However, compared to other Germanic languages, it has preserved a relatively rich system of both noun and verb morphology. German distinguishes between three genders (masculine, feminine and neuter), four cases (nominative, accusative, dative and genitive) and two numbers (singular and plural). These distinctions apply to nouns and their accompanying articles and adjectives. The German verb paradigm also distinguishes between two numbers (singular and plural) and three persons (first person second person and third person), though German verbs also appear with a rich system of prefixes, particles and other elements that combine with verbs to form compounds.

2.1.3.1 Inflectional verb morphology in German

Like English verbs, German verbs are marked for tense, aspect and mood, and for subject-verb agreement (person and number). However, German has much richer verb morphology than English and distinguishes between most of the different person/number combinations in both the present and the past tense. Thus, in the present tense, the 1st, 2nd and 3rd person singular and the plural are marked with specific suffixes. The suffix *-en* is ambiguous for 1st and 3rd person plural (and the infinitive) and the suffix *-t* is ambiguous for 3rd person singular and 2nd person plural.

Table 1 shows the present tense paradigm for the *weak* verb Sagen (to Say) where *weak* denotes a verb that has a regular inflectional paradigm. These verbs can be distinguished from so-called *strong* verbs, which are conjugated irregularly and involve additional vowel changes in the verb stem (Bittner, 2003).

Table 1: Present tense inflections in German

Person	**Singular**	**Plural**	**Infinitive**
1st	ich **sag**-e I say	Wir **sag**-en We say	Sag-en to say
2nd	du **sag**-st you say	Ihr **sag**-t You say	
3rd	er/ sie/ es **sag**-t he/ she/ it say-s	Sie **sag**-en They say	

Like English, German expresses differences in mood primarily through the use of modal verbs in combination with an infinitive. However, whereas the English infinitive is a bare stem, the German infinitive carries the infinitival morpheme -en, which makes it much easier to distinguish between infinitives and finite verb forms in early child German than it is in early child English.

In terms of word order, German is a V2 language, in which finite verbs are tied to second position in main clauses, and preceded by a single constituent, which functions as the clause topic. Non-finite verbs, on the other hand, are tied to utterance-final position. As a result, finite and non-finite verbs tend to occur in different positions in the sentence. For example, in contrast to English, where finite verbs occur in the same position as infinitives with respect to their complements (e.g. 'Mummy kicks the ball' versus 'Mummy can kick the ball') in German, finite verbs occur before their complements and infinitives occur after their complements in main clauses (e.g. 'Mama tritt den Ball' (Mummy kicks the ball) versus 'Mama kann den Ball treten' (Mummy can the ball kick-INF)).

Finally, it is worth noting that German forms questions via subject main-verb inversion. This means that finite verb forms are more frequent in German than they are in English, since the majority of German questions include a finite lexical verb, whereas the vast majority of English questions contain a finite auxiliary and a non-finite lexical verb.

2.2 Theories of the acquisition of morpho-syntax

In the sections above the most important linguistic concepts and terminology for this thesis were explained. In the following sections the assumptions of two theoretical approaches to the acquisition of inflectional verb morphology will be presented. The key debate centres around whether the child has innate knowledge of inflection onto which she maps the language she is learning or whether she constructs knowledge of inflection on the basis of analysis of the input to which she is exposed. In order to better understand this debate, we will outline the general assumptions behind each approach. We will then introduce the key cross-linguistic phenomenon that is the focus of this thesis: the Optional Infinitive phenomenon, before discussing some specific nativist and constructivist models of this phenomenon, including the two models whose predictions are tested in the this thesis.

2.2.1 Nativist approaches to language acquisition

Until the 1960s language acquisition research was dominated by the Behaviourist view that language development could be explained in terms of general principles of learning and reinforcement (Skinner, 1957). However, the dominance of this view was undermined by the publication of Chomsky's (1957) book: *Syntactic Structures* and of his 1959 review of Skinner's book:

Verbal Behavior. Chomsky criticised Behaviourism for failing to understand the infinite generativity of language and argued for a nativist approach to language acquisition based on his ideas about generative syntax. Chomsky's ideas have evolved over the last 50 years and his original formulations have been replaced by alternative theories of syntax, including Government and Binding theory (Chomsky, 1982) and the Minimalist Program (Chomsky, 1993). However, they led to a critical shift in the way that both linguists and psychologists thought about language, and the emergence of a new nativist approach to language acquisition, according to which language was viewed not as learned behaviour, but rather as a generative system of categories and rules that was part of humans' genetic endowment and simply had to be mapped onto the language or languages to which the child was exposed.

Chomskyan nativism assumes that all humans are endowed with innate grammatical knowledge called Universal Grammar (UG). UG represents the initial linguistic state of human beings, that is, the genetic equipment necessary for acquiring a language (c.f., Guasti, 2004), and includes the principles that are common to all human languages. This innate structure develops towards the target language as a result of tuning by input from the environment (Haegeman, 1994). In more recent formulations, this is achieved through a process of parameter-setting, where a parameter is a rule that can take one of a small set of values depending on the language being learned. For example, languages can be divided into obligatory-subject languages (in which all independent clauses require an explicit subject) and null-subject languages (in which independent clauses can lack an explicit subject) and this distinction can be formalized in terms of a pro-drop parameter that can be set to 'on' or 'off' depending on the language. The child's task is then to decide whether her language allows null subjects or requires obligatory subjects and to set the pro-drop parameter accordingly.

The idea that the input plays a relatively minor role in language learning can also be extended to the acquisition of inflectional verb morphology. For example, nativists argue that, although the inflectional verb morphology of any particular language clearly has to be learned, this learning reflects the mapping of the morphemes encountered in the input onto innately-given categories and paradigms.

2.1.1.1 Nativist theories of the acquisition of verb inflection

The conventional nativist position with respect to inflectional morphology (e.g., Pinker, 1999) is that regular inflectional morphology is part of syntax and is to be explained in terms of syntactic categories and rules. Nativists assume that, in addition to general rules about syntactic operations, children also have innate knowledge of inflectional morphology, which includes the basic categories of INFL (Inflection), TNS (Tense), and AGR (Agreement). Children use this knowledge to map the inflections that they hear in the input to innately specified paradigms, with the result that their early knowledge of verb morphology is fully productive. That is to say, they are able to apply any inflection that they know to any verb that they know from the earliest observable stages. For example, Wexler (1998) argues that young children have Very Early Knowledge of Inflection (VEKI), having mapped the inflectional morphemes in their input onto their innately specified paradigms before they start to talk. Their use of the inflectional morphemes that they know is therefore fully productive and inflectional errors such as subject-verb agreement errors are vanishingly rare.

Since children's knowledge of inflection is assumed to be part of syntax, it also interacts with their knowledge about the syntax of their language, including their knowledge of word order rules. Many nativist accounts assume that this knowledge is also adult-like from the earliest observable stages. For example, in addition to arguing for Very Early Knowledge of Inflection, Wexler (1998) also argues for Very Early Parameter Setting (VEPS). For example, he argues that German-speaking children have already set the V2 parameter before they start to talk – and hence know that finite verbs take second position in main clauses.

2.2.2 Constructivist approaches to language acquisition

Constructivist approaches to language acquisition are related to American functionalism, which is characterised by the idea that grammar and language use are closely connected (e.g. Bybee & Scheibman, 1999; Croft, 2003; Greenberg, 1966; Givón, 1976, 1979; Haiman, 1985, 2011; Hopper & Thompson, 1980; 1984; Thompson, 1988; 1998)

A key assumption of constructivist approaches is that children are equipped with fundamental socio-cognitive abilities that allow them to learn language. These include intersubjectivity, intention-reading (Bates, 1979; Bakeman & Adamson, 1984) and cultural learning (Tomasello, 1992; 2000a; Tomasello, Kruger & Ratner, 1993). According to Tomasello (2003), children as young as 9-12 months show these abilities through gaze following, social referencing and imitative learning. Together with general cognitive skills like the ability to form concepts and categories and to acquire symbols and their underlying conceptualizations (Tomasello, 1992; 2003), these socio-cognitive abilities provide the basis for learning.

Usage-based theories do not assume any innate linguistic knowledge, though they do assume that the ability to learn language is innate. The acquisition of language structures and categories results from generalizations over instances of language use. Children's desire to communicate and to use language is the motivation for acquiring a language. Children develop their knowledge, because they use domain-general learning mechanisms such as entrenchment and abstraction to construct linguistic knowledge based on what they hear in the environment.

At the age of 18 to 24 months children start to produce multi-word utterances (Bates, Bretherton, Snyder, et al., 1988; Clahsen, 1986). At this early stage, many of children's multi-word utterances are either rote-learned holophrases, which are combinations of contextualised meanings and sound strings without any internal structure, or instances of lexically-specific patterns (e.g., Lieven, Pine, & Baldwin, 1997; Lieven, Salomo & Tomasello, 2009; Pine & Lieven, 1997). For example, Lieven et al. (1997) showed that a large proportion of English-speaking children's early multi-word utterances could be classified as either frozen utterances or instances of slot-and-frame patterns, consisting of a variable slot and a lexically-specific frame (e.g., *I can't* + VERB; *where's* the + NOUN + *gone?*). Based on information in the input (e.g. the fact that different instances of the same pattern are encountered with variation in only one position in the utterance), children learn to substitute different words into the slots in these lexically-specific structures. As a wider range of sequences are encountered, children analogise across sequences, and these sequences are gradually analysed into their component parts, allowing for greater productivity of use, and, ultimately, adult-like grammatical knowledge.

This kind of analysis is perhaps best exemplified by Tomasello's (1992) Verb-Island hypothesis, which is based on a diary study of his daughter's speech between the ages of 1;3 and 2;0. This study revealed little overlap in the constructions used with individual verbs. Tomasello (1992) therefore argued that each verb was an "island" in the child's grammar, with each "verb island" having its own syntax and semantics. According to this view, verbs are initially used in their own unique set of utterance-level schemas and generalised on the basis of the child's observations about what comes before and after the verb, and only later does each verb begin to be used in new *utterance*-level schemas (and with more variable tense and aspect morphology). In order to arrive at adult-like abstract constructions (e.g., S-V-O), children have to generalize and analogize across lexically specific patterns that they have stored in memory. Tomasello (2003) suggests that children generalise by using structure mapping (Gentner, 1983) to create analogies across lexically specific constructions, and functionally-based distributional analysis to group together words with similar functions that appear in similar positions in sentences. For example, the child may group together *cut* and *drink* into the category verb, because they denote actions and appear in similar constructions in the child's input (e.g. X + it, I'm + X-ing + it).

2.2.2.2 Constructivist theories of the acquisition of verb inflection

Constructivist accounts of morphological development (e.g., Bybee, 1995, 2001; Pizzuto & Caselli, 1992; Rubino & Pine, 1998; Pine, Lieven & Rowland, 1998; Gathercole, Sebastian & Soto, 1999; Aguado-Orea, 2004;

Pine, Conti-Ramsden, Joseph, Lieven & Serratrice, 2008) argue that children start their morphological development without any knowledge of abstract categories of verb, inflection or agreement. They acquire utterances as whole forms from the input (e.g., I'm playing; It fits), which include ready-inflected forms that are initially stored in memory as unanalysed wholes. Constructivist accounts assume that early correct performance may reflect rote learning (Ambridge & Lieven, 2011). In the beginning, children are not aware of the internal morphological structure of the verb forms that they use. Later they recognise similarities that are shared by different inflected forms. At this stage, generalization is limited, and children's knowledge of inflection is still highly item-based (e.g., Lieven, 2010; Tomasello, 2000a). Later in development, children use categorisation and generalisation to abstract across these forms, and thereby learn to use inflectional morphology more productively. For example, they are able to produce forms of verbs that they have not heard in the input as evidenced by their ability to inflect nonce verbs in novel word learning experiments.

An important factor in Constructivist models of the acquisition of inflectional verb morphology is the frequency with which different verbs and verb forms occur in the child's input (see Ambridge, Rowland, Theakston, & Kidd, 2015; Ellis, 2002 for reviews). Studies of children's speech have found that the more frequent a verb is in the children's input, the earlier it is acquired (e.g., de Villiers, 1985; Naigles & Hoff-Ginsberg, 1998; Theakston, Lieven, Pine & Rowland, 2004), and that frequency also affects the processing and grammatical acceptability of verb forms. There are two different often discussed types of frequency: token frequency and type frequency. Token frequency is the total frequency with which a form is found in a dataset (e.g., the number of times the form ‘play’ appears in a corpus, including different inflected forms of the verb such as ‘plays’, ‘playing’ and played). The token frequency of an inflectional pattern establishes the construction and increases the strength of the representation. Type frequency refers to the number of different lexical items that occur in a certain pattern (e.g., the number of verbs that appear in 3rd singular form in a corpus). Patterns that appear more often with different verbs are easier to generalise over, and are thus acquired earlier (Dąbrowska, & Szczerbinski, 2006). High type frequencies can also lead to greater productivity (Bybee, 1985; 1995). The frequency distribution of forms in the input, can thus provide an explanation of what patterns the child uses productively and when errors occur. Other factors like phonological regularity and position in the utterance can also play a role.

2.3 The Optional Infinitive Phenomenon

A key challenge facing both nativist and constructivist theories of the acquisition of inflectional verb morphology is to explain the pattern of verb-marking errors in young children’s speech. For example, between the ages of 2 and 4 years, English-speaking children often produce zero-marked verb forms in contexts that require a past tense or a third person singular (3sg) present tense form (e.g. ‘That go there’ or ‘We go shops yesterday’). Early nativist accounts of these errors (e.g. Bloom, 1990; Valian, 1991) assumed that they reflected the dropping of inflections due to performance limitations in production. Early constructivist accounts (e.g. Brown, 1973) assumed that they reflected the use of the bare stem due to incomplete knowledge of the target inflection. However, more recent cross-linguistic analyses (e.g. Rizzi, 1993/1994; Wexler, 1994) have revealed that, in languages other than English, the equivalent errors often include verb forms marked with an infinitival morpheme. For example, in the following German examples, taken from Poeppel and Wexler (1993), the verb is marked with the infinitival morpheme: -en and occurs in utterance-final rather than verb-second position, which is the position occupied by the infinitive in main clauses in German.

1) *Hubschrauber putzen

   Helicopter clean-INF

   Clean helicopter

2) *Thorsten Cäsar haben

   Thorsten Caesar (=doll) have-INF

   Thorsten have Caesar

Since these errors clearly reflect the use of an infinitive rather than an unmarked verb form, they cannot be explained in terms of inflection drop. This has led to the view that verb-marking errors across languages (including the incorrect use of zero-marked forms in English) reflect the use of infinitive and other non-finite forms in contexts in which a finite verb form is required by the adult grammar. These errors are sometimes referred to as Root Infinitive (RI) errors (Rizzi, 1993/1994). However, since they tend to occur during a stage in which the child is also producing correct finite forms, they are also often referred to as Optional Infinitive (OI) errors (Wexler, 1994), and the period during which they occur as the Optional Infinitive (OI) Stage.

2.3.1 Nativist models of the OI phenomenon

There are a number of different Nativist models of the OI phenomenon. For example, Hyams (1996) argues that OI errors reflect the fact that children can leave functional heads such as I (Inflection) underspecified in the underlying representation of the sentence; and Rizzi (1993/1994) argues that children have the option of truncating lower down the clause than adults, with a structure truncated below TP (Tense Phrase), resulting in a non-finite clause. However, these accounts cannot fully explain the pattern of OI errors across languages. For example, Rizzi's account predicts OI errors in declaratives but not in Wh- questions as Wh- questions cannot be truncated below TP. However, English speaking children make OI errors in both declaratives and Wh- questions.

The most comprehensive nativist model of the OI phenomenon is provided by Wexler's Optional Infinitive Hypothesis (Poeppel & Wexler, 1993; Wexler, 1994; 1998). According to this model, by the time children begin to produce multi-word utterances, they have already set all the inflectional and phrase structure parameters of their language (i.e. they have engaged in Very Early Parameter Setting). However, their grammars allow the optional use of non-finite forms in utterances in which a finite form would be required from an adult perspective. The reason that tense and agreement marking are optional in the child grammar is that young children are subject to a Unique Checking Constraint (UCC), which prevents them from checking items against more than one functional category. The child is therefore unable to check both Tense and Agreement in the underlying representation of the sentence and produces non-finite verb forms in finite contexts as a result. The presence of the UCC in the child grammar might seem to predict that children in the OI stage will always produce untensed verb forms. However, Wexler (1998) argues that children are subject to a number of competing constraints, and that they attempt to minimize the number of constraints that they violate when producing an utterance. When a child produces a non-finite verb form in a finite context, she violates the pragmatic constraint that requires tense and agreement marking, but satisfies the UCC. When a child produces a correct finite form, she violates the UCC but satisfies the pragmatic constraint. The co-existence of these two constraints explains why the child’s grammar allows both finite and non-finite forms in finite contexts. The assumption that the child has already set all the inflectional and phrase structure parameters of the language explains why the non-finite verb forms produced by young children tend to pattern correctly with respect to other elements in the utterance (e.g. following rather than preceding their complements in German).

The OI hypothesis has two key strengths as an account of the OI stage. First, it provides a comprehensive account of the cross-linguistic patterning of OI errors. For example, it can explain why OI errors are common in obligatory subject languages like English, French and German and rare in null-subject languages like Italian and Spanish. According to Wexler (1998), this reflects the fact that finite lexical verbs do not need to be checked against Agreement in null-subject languages, and so the UCC has no effect on Italian- and Spanish-speaking children.

Second, the OI hypothesis can also be applied to the cross-linguistic pattern of verb-marking error in children with Developmental Language Disorder (DLD). For example, Rice and Wexler (1996) and Rice and colleagues (1997) provide Extended Optional Infinitive (EOI) analyses of the pattern of verb-marking error in English- and German-speaking children with DLD, respectively (see Chapter 3).

However, the Optional Infinitive Hypothesis is also subject to a number of important weaknesses. First, because it assumes Very Early Knowledge of Inflection (VEKI), Wexler's account predicts that OI errors are the only kind of verb-marking errors that children will make during the OI stage. For example, children should not make subject-verb agreement errors such as 'I wants it' or 'They goes there', either in OI languages like English and German or in non-OI languages such as Italian and Spanish. At first sight, the cross-linguistic data appear consistent with this prediction. For example, in their review of the cross-linguistic data on rates of subject-verb agreement error, Hoekstra and Hyams (1998) report overall error rates of less than 5% in German, Italian, Spanish and Catalan. However, in their work on Brazilian Portuguese and Castilian Spanish, Rubino and Pine (1998) and Aguado-Orea and Pine (2015) show that the kind of low overall error rates reported by Hoekstra and Hyams hide much higher error rates in lower frequency contexts. Since these errors tend to reflect the over-use of a particular high frequency form, some nativist researchers (e.g. Salustri & Hyams, 2006; Grinstead, De la Mora, Vega-Mendoza & Flores, 2009) have argued that this form can be analysed as a Root Infinitive Analogue – and errors involving this form as analogous to OI errors. However, Root Infinitive Analogue accounts cannot explain why the children making such errors also tend to make OI errors in their speech, albeit at low rates.

Second, because the OI Hypothesis assumes that OI errors reflect tense optionality, it predicts that there will be no difference in the contexts in which correct finite forms and OI errors occur. However, there is now substantial evidence that OI errors and correct finite forms tend to occur in different contexts, with OI errors occurring in modal contexts (the Modal Reference Effect) and with eventive rather than stative verbs (the Eventivity Constraint), and correct finite forms occurring in non-modal contexts with stative rather than eventive verbs. This pattern has been reported in a number of OI languages, including Dutch (Jordens, 1990; Wijnen, 1998); French (Ferdinand, 1996); German (Ingram & Thompson, 1996), Russian ((Van Gelderen & Van der Meulen, 1998) and Swedish (Josefsson, 2002) and some nativist accounts have attempted to deal with it more explicitly. For example, Hoekstra and Hyams (1998) argue that the infinitival morpheme carries an irrealis feature which is responsible for the modal reading of OI errors and for the fact that OI errors are restricted to eventive verbs. However, Hoekstra and Hyams' account predicts that, in OI languages in which the infinitive is marked with an infinitival morpheme, children will *only* produce OI errors in modal contexts and with eventive verbs, and the cross-linguistic data do not support this prediction. Moreover, since the observed pattern actually mirrors the way finite forms and infinitives pattern in the input language, it seems more likely that the Modal Reference Effect and the Eventivity Constraint are input-driven phenomena (see section 4.2 below).

A third and final weakness is that, because the OI hypothesis is designed to differentiate between languages in which OI errors do and do not occur, it predicts a qualitative difference between OI and non-OI languages. However, through online databases with language corpora more data have become available from a wider range of languages, it has become increasingly clear that cross-linguistic variation in the rate at which children make OI errors does not reflect a single qualitative difference between OI and non-OI languages, but more continuous quantitative variation across OI and non-OI languages. For example, Phillips (1995) reviews data from children learning 5 OI languages (Dutch, English, French, German and Swedish) and 4 non-OI languages (Catalan, Hebrew, Italian and Spanish) and argues that there is continuous variation in rates of OI errors from high in English and Swedish through moderate in Dutch, French and German to low (but not zero) in Catalan, Hebrew, Italian and Spanish. More recent nativist models of the OI stage have attempted to explain this variation. For example, the Variational Learning Model (VLM) proposed by Yang (2002; 2004), is a model of language acquisition that combines a nativist parameter-setting approach with a statistical learning approach. The VLM models the child's grammar as a population of innately derived hypotheses whose composition changes during the course of learning. The child initially entertains a finite number of grammars with different parameters (e.g. the null subject parameter and the Tense marking parameter) for which she will ultimately select the correct settings on the basis of the linguistic input. During the acquisition process, several different grammars, each with different settings, compete with each other. Those grammars that are consistent with the input are rewarded, which increases the likelihood that they will be used in the future. Those grammars that are not consistent with the input are not rewarded, which decreases the likelihood that they will be used in the future. In the case of the tense marking parameter, this means that there is a period in development in which children learning +Tense languages entertain the possibility that they are learning a -Tense language and so produced both OI errors and correctly tensed forms. Legate and Yang (2007) show that, if one assumes that children gradually abandon the -Tense grammar in response to the number of overtly tensed forms in the input, Spanish-speaking children will abandon the -Tense grammar, and hence stop making OI errors, relatively early and English-speaking children will abandon the -Tense grammar relatively late, with French-speaking children falling somewhere in-between. It is therefore possible to explain cross-linguistic variation in the time that it takes children to emerge from the OI stage (and, by implication, in the rate at which they make OI errors) in terms of the amount of evidence for the +Tense grammar that is available in the input to which they are exposed.

The VLM is clearly an improvement on the OI Hypothesis in the sense that it provides a means of explaining the continuous variation that has been reported in the rate of OI errors across languages. However, it makes similar predictions to the OI Hypothesis in other respects. For example, because it explains OI errors in terms of an incorrect parameter setting at the level of the underlying grammar, it predicts that correctly tensed forms and OI errors will occur in free variation in the child's speech – and hence cannot explain the data on the Modal Reference Effect or the Eventivity Constraint. Since the VLM has also yet to be applied to children with DLD, in this thesis, we have chosen to focus on the OI hypothesis as the most comprehensive nativist account of the OI stage – and it is this nativist model that we will evaluate in the studies that follow.

2.3.2 Constructivist models of the OI phenomenon

Research on the OI stage has been conducted primarily within the nativist tradition. However, the similarity between the patterning of children's OI errors and the way that infinitives pattern in OI languages has led some researchers to argue for a constructivist account of OI errors. For example, Wijnen, Kempen and Gillis (2001) argue that the tendency for Dutch-speaking children to produce infinitives instead of finite forms during the early stages can be explained in terms of the higher conceptual transparency and increased salience of infinitives in sentence-final position in the input language.

According to this view, OI errors are truncated modal structures which tend to be learned earlier in Dutch than simple finite structures, because the lexical verb in these structures occurs in utterance-final position, whereas the lexical verb in simple finite structures occurs earlier in verb second position. Because it sees OI errors as truncated modal structures, Wijnen et al.'s account provides a natural explanation of the Modal Reference Effect and the Eventivity Constraint. Moreover, because it includes a role for processing factors such as conceptual transparency and perceptual salience, which are assumed to interact with the distributional properties of the input language, it also has the potential to explain quantitative variation in the rate at which children make OI errors across different languages. However, Wijnen et al.'s account focuses only on OI errors in Dutch and is not sufficiently well specified to make quantitative predictions in its own right.

A more comprehensive constructivist model of the OI stage is provided by Freudenthal and his colleagues' Model of Syntax Acquisition in Children (MOSAIC). MOSAIC is a relatively simple computational model of language learning, which takes as input corpora of orthographically transcribed child-directed speech and learns to produce as output utterances that become progressively longer as learning proceeds. As a result of these characteristics, MOSAIC can be used to generate corpora of ‘child-like’ utterances at different ‘stages’ of development, and hence to simulate the behaviour of children learning different languages across a range of MLU values.

In a series of studies, Freudenthal and his colleagues have shown that MOSAIC can simulate quantitative differences in the rate of OI errors across a number of different languages in terms of the interaction between an utterance-final (and later edge-based) bias in learning and the distributional properties of the input language (Freudenthal, Pine & Gobet, 2006, 2010, Freudenthal, Pine, Aguado-Orea & Gobet, 2007; Freudenthal, Pine, Jones & Gobet, 2015a; 2015b). The model learns OI errors from modal and other complex constructions in the input, and its utterance-final bias results in high rates of OI errors in languages like Dutch and German, in which infinitives are tied to utterance-final position, and very low rates of OI errors in Spanish in which utterance-final infinitives are much less common. The model is also able to simulate the tendency for OI errors in German and Dutch to have modal semantics and to be restricted to eventive verbs (Freudenthal, Pine & Gobet, 2009). However, as Freudenthal et al. (2010) point out, it does not provide a comprehensive model of the OI stages because it substantially underestimates the rate of OI errors in English.

To deal with this problem, Freudenthal et al. (2010) propose a Dual-Factor Model of verb-marking error in which some errors reflect the learning of infinitives from modal structures and others reflect the tendency of the child to default to the most frequent form of the verb – which in English is the bare stem and is indistinguishable from the infinitive. The Dual-Factor Model can explain both the very high rate of OI errors in English and the tendency of children learning more highly inflected languages to use the most frequent form of the verb in inappropriate contexts. For example, Freudenthal et al. (2015a) show that a version of MOSAIC that combines the model's utterance-final bias in learning with a frequency-based defaulting mechanism can simulate both the very high rate of OI errors in English, and the tendency of Spanish-speaking children to produce third person singular (3sg) forms in non-3sg contexts (Aguado-Orea & Pine, 2015; Radford & Ploenning-Pacheco, 1995).

MOSAIC and the Dual-Factor Model have so far only been used to simulate data on typically developing children, but the ideas implemented in MOSAIC have been incorporated into Leonard and his colleagues' Competing Sources of Input account of the pattern of verb-marking deficit in children with DLD (Leonard, 2014; Fey, Leonard, Bredin-Oja & Deevy, 2017). According to this view, OI errors in children with DLD reflect the inappropriate extraction of non-finite structures from more complex structures in the input (e.g. 'doggie like biscuits' from 'Does the doggie like biscuits' and 'Mummy build a tower' from 'He helped Mummy build a tower'). This is due to a weakness in their ability to process the dependency between the non-finite form later in the sentence and the finite form earlier in the sentence. Leonard and his colleagues provide support for this view using a variety of different experimental paradigms (e.g., Leonard & Deevy, 2011; Leonard, Fey, Deevy & Bredin-Oja, 2015; Purdy, Leonard, Weber-Fox & Kaganovich, 2014). They also provide evidence that at least some OI errors in English-speaking children with DLD reflect a process of defaulting to the bare stem. For example, Kueser, and colleagues (2018) replicate a study by Räsänen, Pine and Ambridge (2014), which shows that English-speaking children's tendency to produce bare forms in 3sg elicitation contexts is significantly correlated with the relative frequency with which particular verbs occur as bare rather than 3sg forms in English child-directed speech. The Kueser et al. (2018) study shows the same effect in a group of children with DLD and a group of language-matched controls, with the children with DLD also producing significantly more bare forms in 3sg contexts than the typically developing children. The implication is that the Dual-Factor Model may be able to account for the pattern of verb-marking error in both typically developing English-speaking children and English-speaking children with DLD — though whether it can also account for the cross-linguistic pattern of verb-marking error in children with DLD remains to be seen.

To summarise, the Dual-Factor Model provides a good fit to the cross-linguistic data on typically developing children and there is also evidence for the operation of its key mechanisms in English-speaking children with DLD. It is therefore currently the most comprehensive constructivist model of the OI phenomenon, and hence the model that we will focus on in the studies that follow.

CHAPTER 3: Children with developmental language disorder (DLD)

3.1 Developmental Language Disorder (DLD)

Research on language acquisition attempts to identify the processes by which children acquire adult-like knowledge of the language or languages to which they are exposed. However, these processes can be disrupted in children for a variety of reasons, including hearing loss, a generalised cognitive deficit, and different kinds of brain injury. Developmental Language Disorder refers to a significant deficit in language ability that cannot be explained in terms of such factors, and is typically diagnosed in children from around three years of age (Tager-Flusberg & Cooper, 1999).

Research on children with DLD can be driven both by the motivation to develop practical ways of supporting these children's language development and by the motivation to increase our understanding of the language acquisition process. A comprehensive theory of language acquisition must ultimately be able to explain the language learning process in children with language problems as well as typically developing children, and differences in the developmental profiles of children with DLD and typically developing children. Furthermore, it should have the potential to shed important light on the processes by which different aspects of language are acquired, and how these can be disrupted by deficits either in the linguistic knowledge available to the child or in the child's language processing abilities.

3.1.1 Definition and Prevalence of DLD

Developmental Language Disorder refers to 'a significant deficit in language ability that cannot be attributed to hearing loss, low non-verbal intelligence or neurological damage' (Leonard, 2014: 3). Tomblin, Records, Buckwalter, Zhang, Smith and O'Brien (1997) report that approximately 7% of the preschool-aged population exhibit this kind of developmental profile, with males more likely to be affected than females (8% versus 6%, respectively). In the past, this group of children was referred to as children with Specific Language Impairment (SLI). However, in recent years, there has been growing dissatisfaction with the term SLI (Ebbels, 2014), and a new consensus has emerged in favour of the term 'Developmental Language Disorder' (Bishop, Snowling, Thompson, Greenhalgh & the CATALISE-2 consortium, 2017). Developmental Language Disorder is therefore the term that we will use in the present thesis. It should be noted that this change in terminology also has implications for precisely which children the new term should be applied to. Thus, when describing the results of their Delphi study, Bishop et al. (2017) note: "The term, 'Developmental Language Disorder' (DLD) was endorsed for use when the language disorder was not associated with a known biomedical aetiology. It was also agreed that (a) presence of risk factors (neurobiological or environmental) does not preclude a diagnosis of DLD, (b) DLD can co-occur with other neurodevelopmental disorders (e.g. ADHD) and (c) DLD does not require a mismatch between verbal and nonverbal ability" (Bishop et al., 2017: 1068).

3.1.2 Characteristics of children with Development Language Disorder

Children with DLD constitute a heterogeneous population (Leonard, 2014). They may show a delayed start in language learning, slow language development and deficits in a variety of language domains, including phonology, word learning, morpho-syntax and pragmatics (Kauschke, 2012). If these difficulties remain untreated, DLD can have significant consequences later in life. Conti-Ramsden and Botting (1999) describe a consolidation of the language profile, which makes it progressively more difficult to catch up with typically developing children. Children are at risk of experiencing reading and other academic difficulties (e.g., Conti-Ramsden, Durkin, Simkin, & Knox, 2009; Leonard, 1998; Snowling, Bishop, & Stothard, 2000), and only approximately 25% of children with DLD resolve their problems spontaneously (Law, Boyle, Harris, Harkness, & Nye, 2000).

3.1.3 Inclusion criteria for children DLD

DLD is defined partly by exclusion (i.e. by excluding children whose language problems can be explained by factors such as hearing loss or brain injury). However, it also requires the researcher or therapist to decide what constitutes 'a significant deficit'. In the research literature, decisions have generally been made by setting a quantitative inclusion criterion of either 1 or 1.5 Standard Deviations below the mean (e.g. Leonard, 1998). However, this kind of quantitative approach has been questioned (e.g. Dollaghan, 2004), and it has been argued that a qualitative description of the child's overall language profile might be more useful, particularly in a therapeutic context. It is also worth noting that, even when quantitative criteria are used, these have often been applied to measures based on different kinds of data (e.g. measures based on naturalistic speech data and measures based on performance in standardised tests). This makes it difficult to compare results across studies. In the present thesis, the inclusion criterion used to classify the child as showing a significant language deficit is performance of more than 1.5 standard deviations below the mean on selected standardised tests (i.e. the Clinical Evaluation of Language Fundamentals - Preschool 2 UK (CELF

Preschool-2) (Wiig, Secord, & Semel, 2004) for the English-speaking children and the Patholinguistische Diagnostik bei Sprachentwicklungsstörungen 2nd Edition (PDSS) (Kauschke & Siegmüller, 2009) and the Sprachentwicklungstest für Kinder 3rd Edition (SETK) (Grimm, 2015; 2016) for the German-speaking children.

3.2 Patterns of deficit and clinical markers in DLD

There are two main approaches to identifying patterns of deficit and clinical markers in DLD. The first is simply to identify areas in which children with DLD perform significantly worse than typically developing children. The second is to identify tasks which are able to distinguish between typically developing children and children with DLD with good levels of sensitivity (i.e. that correctly identify a high proportion of children who have the disorder) and specificity (i.e. correctly classify a high proportion of unaffected children as not having the disorder).

The first of these approaches typically involves comparing children with DLD with groups of both age-matched and language-matched controls, with the aim of identifying areas where affected children are performing even worse than would be expected on the basis of their current language level. For example, studies of word learning in DLD have compared the ability of children with DLD to learn new words with that of both age-matched and vocabulary-matched controls, and studies of verb-marking in DLD have compared the ability of children to provide verb inflections in obligatory contexts with age-matched and MLU-matched controls. These studies have revealed both word learning and morphological deficits in English-speaking children with DLD.

However, the pattern of deficit appears to be different in each case. Thus, on the one hand, Kan and Windsor (2010), in their meta-analysis of studies of the word learning deficit in DLD, conclude that there is good evidence of a deficit relative to age-matched controls, but not relative to language-matched controls. On the other hand, in their work on the morpho-syntactic deficit in DLD, Rice Wexler & Cleave (1995) and Rice, Wexler and Hershberger (1998) report deficits in tense and agreement marking relative to both language-matched and age-matched controls.

These findings seem to suggest that children with DLD have problems with both word learning and morpho-syntax, but show a particular deficit in tense and agreement marking. However, the picture is complicated by the fact that the morpho-syntactic deficit in DLD tends to present in different ways in different languages. Thus, although English-speaking children with DLD tend to show a protracted period during which they omit tense and agreement markers from their speech relative to both age- and language-matched controls, tense and agreement marking appear to be much less affected in Spanish-speaking children with DLD. For example, Bedore and Leonard (2005) report that the Mexican-Spanish children in their study showed only a very slight deficit in tense and agreement marking relative to age-matched controls and no deficit at all relative to language-matched controls, though they did show deficits relative to both groups in their provision of definite articles and object clitics.

The second approach, which is aimed at identifying clinical markers of DLD, seeks to measure the sensitivity and specificity of specific tasks in differentiating between children with DLD and typically developing children.

Studies using this approach with English-speaking children have also identified problems with tense and agreement marking as a good diagnostic. For example, Rice and Wexler (1996) found that 80% of children with DLD struggled with the marking of present tense 3rd person singular -*s*, past tense -*ed* and the inflection of auxiliary *do* and copula *be*. More specifically, they found that, when the mastery criterion was set at 80% correct production, 97% of 5-year-olds with DLD failed to show mastery of tense marking, whereas 98% of their age-matched peers succeeded. Similarly, Conti-Ramsden (2003) showed that, while a noun-marking task was not useful for diagnosing DLD, a past tense marking task showed good sensitivity and specificity, though Klee, Gavin & Stokes' (2007) review concluded that tasks with single morpheme markers were not as successful at differentiating between affected and unaffected children as tasks using a composite verb-marking measure.

Other studies have shown an advantage for different psycholinguistic markers of DLD. For example, Conti-Ramsden, Botting and Farragher (2001) compared a past tense task, a third person singular task, a non-word repetition task and a sentence repetition task – and found that, while all of these tasks showed good sensitivity and specificity, sentence repetition was the best psycholinguistic marker of DLD. Sentence repetition also has the advantage over verb-marking tasks that it appears to be a good diagnostic of DLD across a range of different languages, including Cantonese (Stokes, Wong, Fletcher & Leonard, 2006), Czech (Smolik & Vavru, 2014), and French (Leclercq, Quémart, Magis & Maillart, 2014), though the relevant studies do not always include the kind of sensitivity and specificity analyses reported by Conti-Ramsden et al. (2001).

To summarise, there is good evidence that children with DLD show deficits in word learning and in the use of inflectional morphology relative to typically developing children. However, children with DLD only appear to show a word learning deficit relative to age-matched controls, and, while English speaking children with DLD show deficits in tense marking relative to language matched controls, the pattern of morphological deficit found in children with DLD appears to vary across languages. Since, this thesis is concerned with the pattern of verb-marking deficit in children with DLD in English and German, in the following sections we briefly describe the developmental profile of children with DLD in English and German, before ending with a description of nativist and constructivist theories of the verb-marking deficit in children with DLD.

3.2.1 Developmental Language Disorder in English

The prevalence of DLD in English is between 3% and 7%, depending on age and definition (Norbury, Gooch, Wray, Baird, Charman, Simonoff, Vamvakas & Pickles, 2016; Tomblin et al., 1997). English-speaking children with DLD can show deficits in a number of different language domains. For example, as we have already seen, they typically show deficits in word learning relative to age-matched controls (Kan & Windsor, 2010), and syntactic impairments have also been reported (van der Lely, 2005). However, English-speaking children with DLD appear to have particular problems with tense and agreement marking. Thus, whereas typically developing English-speaking children provide 3sg -s and past tense -ed in more than 90% of obligatory contexts by age 5, English-speaking children with DLD continue to produce bare stems in contexts that require these tense-marking morphemes through the primary school years. For example, in their longitudinal study, Rice et al. (1998) compared rates of provision in 21 children with DLD, 23 age-matched controls and 20 younger language-matched controls, both in their spontaneous speech and in response to elicitation probes. The authors describe a protracted period of development (from 5 to 8 years), in which the children with DLD continued to produce bare stems, and showed significant group differences relative to both age-matched and younger language-matched controls.

3.2.2 Developmental Language Disorder in German

As in English, the prevalence of DLD in German is between 3% and 7% (Neumann, Keilmann, Rosenfeld, Schönweiler, Zaretsky & Kiese-Himmel, 2009). German-speaking children can also show deficits in a variety of different language domains, including phonology, semantics, syntax and pragmatics, with problems in particular areas being more or less visible depending on the child’s stage of development. For example, later in development, text comprehension, narrative skills and metalinguistic operations are also affected.

German-speaking children with DLD appear to show a particular deficit in the acquisition of morpho-syntax (Grimm, 1993; Lindner & Johnston, 1992), though it has been argued that this so-called *dysgrammatism,* should not be seen as an independent disorder in its own right (Motsch, 2004), but rather as one of a number of symptoms that temporarily comes to the fore as children’s language develops (Dannenbauer & Künzig, 1991). German is a morphologically rich language, which makes it relatively easy to identify problems with morpho-syntax. Kilens (1980) reports that, in German, DLD manifests itself in the child's inability to decode grammatical structures and form sentences using age-appropriate morpho-syntactic rules. In comparison with their age-matched peers, German-speaking children with DLD tend to over-use early, and therefore rather simple, structures (Kölliker Funk, 1998). This tendency often persists even when more complex forms have been acquired, so that the child’s production also appears more restricted than that of typically developing children at a similar stage of development (Weinert, 1991).

The problems children with DLD show can be related to the phases of grammatical development in typically developing children described by Clahsen (1988). In the first phase, the transition to two-word utterances is delayed, communication is very simplified, and some parents experience the language as ‘awkward’. In the second phase, children fail to put the verb in second position and to mark agreement between verbs and their subjects. They also omit obligatory elements from their speech to a much greater extent than typically developing children and show delays in the acquisition of the case system. In the third phase, the production of subordinate clauses is delayed and is often accompanied by verb positioning errors.

In this thesis, our focus is on problems in the second phase, where children with DLD children show problems with tense and agreement marking. The predominant error type is the production of the infinitive in contexts in which a finite form is required (Clahsen, 1989, 1991; Clahsen et al., 1997; Kany & Schöler, 1998; Rice et al., 1997; Roberts & Leonard, 1997). Thus, in contrast to English-speaking children, German-speaking children with DLD tend to use verbs that are incorrectly marked with the infinitival -en suffix rather than using unmarked forms of the verb. This is the same kind of error (often referred to as an OI error) that typically developing German-speaking children produce during the early stages. However German-speaking children with DLD continue to make this kind of error further up the age range than typically developing children. There is also some evidence that they produce such errors at higher rates than language-matched controls. Thus, Rice, Noll and Grimm (1997) analysed spontaneous speech samples from 8 children with DLD and 8 typically developing language-matched controls at two measurement points spaced roughly 12 months apart. The DLD group had an age range of 3;9 to 4;8 and a range of MLU in words of 2.00 to 3.66 at Time 1; the typically developing group had an age range of 2;1 to 2;7 and a range of MLU in words of 2.13 to 3.77. The children with DLD produced significantly more OI errors than their language-matched controls at Time 1 (though not at Time 2). Rice et al. also report that there were very few subject-verb agreement or verb-positioning errors in either of the two groups, with both groups tending to produce finite verbs in second position and non-finite verbs in utterance-final position.

Rice et al.'s results are consistent with an Extended Optional Infinitive account of the verb-marking deficit in German-speaking children with DLD (see section 3.1 below). However, they suggest that, if there is an extended OI stage in German-speaking children, it is much shorter than the extended OI stage in English-speaking children, since it was no longer in evidence in Rice et al.'s data when the children with DLD were between 4;9 and 5;8, whereas the extended OI stage in English appears to be in evidence until around age 8. It is also important to note that other studies of German-speaking children with DLD have reported rather different results from Rice et al. (1997). For example, Clahsen, Bartke and Göllner (1997) report relatively high rates of both subject-verb agreement and verb-positioning errors in German-speaking children with DLD. Moreover, in a more recent study of German-speaking children with DLD and Turkish-German bilinguals, Rothweiler, Chilla & Clahsen (2012) report that both groups struggled to produce verbs that were correctly marked for agreement. These findings contradict Rice et al.'s (1997) results, and Rothweiler et al. argue that a potential reason for the discrepancy is that Rice et al. restricted their analysis to only two affixes (3sg -t and 2sg -st). They also conclude that subject-verb agreement errors rather than OI errors are the critical marker for DLD in German (Rothweiler et al., 2012). One possible interpretation of these contradictory findings, which is broadly consistent with the Dual-Factor Model (see section 3.2 below) is that German-speaking children with DLD tend to make both OI errors and agreement (or defaulting) errors, with the former being particularly prevalent at low MLUs.

3.3 Nativist and constructivist accounts of the verb-marking deficit in DLD

It is clear from the previous sections that both English- and German-speaking children with DLD show some kind of verb-marking deficit relative to typically developing children. This deficit tends to be interpreted in different ways by nativist and constructivist researchers, with nativists taking it to reflect a biologically-based deficit in affected children's underlying grammar, and constructivists taking it to reflect a processing deficit that results in faulty processing of the input language. In the final sections of this chapter, we outline the particular nativist and constructivist models that will be the focus of the studies in the rest of the thesis: the nativist Extended Optional Infinitive hypothesis (Rice, Wexler & Cleave, 1995; Rice & Wexler, 1996), and the constructivist Dual-Factor Model (Freudenthal, Pine & Gobet, 2010; Freudenthal, Pine, Jones & Gobet, 2015).

3.3.1 The Extended Optional Infinitive Hypothesis

The Extended Optional Infinitive Hypothesis (Rice & Wexler, 1996) builds on the Optional Infinitive Hypothesis (Wexler, 1994; 1998) described in Chapter 2. According to this view, the verb-marking deficit in children with DLD reflects the same biologically based maturational difference between the child and the adult grammar as the OI stage in typically developing children. However, the Unique Checking Constraint that is responsible for this difference withers away more slowly in children with DLD so that children with DLD are subject to an Extended Optional Infinitive stage that persists for longer and extends further up the MLU range than in typically developing children.

For the purposes of this thesis, the EOI hypothesis makes three predictions about the pattern of verb-marking error in the speech of English- and German-speaking children with DLD and MLU-matched controls. First, since verb-marking errors are assumed to reflect tense optionality rather than knowledge about particular constructions, the EOI hypothesis predicts that correctly tensed forms and OI errors will occur in free variation in the child's speech (e.g. that OI errors will be equally likely in modal and non-modal contexts and with different types of verbs). Since English and German are both OI languages and since OI errors are explained in the same way in both typically developing children and children with DLD, this prediction applies to both English- and German-speaking children. and to both typically developing children and children with DLD.

Second, since the verb-marking deficit in DLD is assumed to reflect an OI stage that extends further up the MLU range than in typically developing children, the EOI Hypothesis predicts significant differences in both English and German in the rate of OI errors relative to MLU-matched controls. It would also seem to predict a similar pattern of deficit across the two languages since, in both cases, the underlying problem is assumed to be the same – though, as we have already seen, if there is an extended OI stage in German, it appears to be more short-lived than the extended OI stage in English.

Third, since OI errors are assumed to reflect a difference at the level of the underlying grammar, as opposed to differences in children's knowledge about particular verbs, the EOI Hypothesis predicts no relation between the rate at which either children with DLD or language-matched controls will produce OI errors with particular verbs and the rate at which those verbs occur in infinitive as opposed to finite form in the language to which children are exposed. There are more modern approaches like the VLM from Legate & Yang (2007), which have acknowledged a greater role for input frequency, and has the potential to explain differences in rates of OI errors across languages (see also chapter 2.3.1). But these approaches still operate at the level of the grammar and cannot explain lexical effects, the VLM predicts that OI errors will occur at more or less the same rate across different verbs (Freudenthal et al., 2010). Furthermore, they would not predict different rates of OI's across different conditions, because they operate at the level of the grammar.

These predictions, and variants on these predictions, will be tested in the studies that follow. In the case of English, this will be done using an elicited production paradigm based on Räsänen et al. (2014), but extended to include both modal and non-modal elicitation contexts. In the case of German, it will be done by analysing rich naturalistic corpora from a German-speaking child with DLD and a language-matched control, and by using the same elicited production paradigm used to collect the English data.

3.3.2 The Dual Factor Model

The Dual-Factor Model (Freudenthal et al. 2015a) is based on a computational model of the OI stage (MOSAIC) that simulates the developmental patterning of OI errors across several different languages (Freudenthal et al., 2006; 2007; 2009; 2010; 2015b). This model assumes that verb-marking errors in both typically developing children and children with DLD reflect two different processes. The first is the learning of OI errors from modal (compound-finite) structures in the input (e.g. English: 'Mummy can kick the ball'; German: 'Mama kann den Ball treten'). The second is a process of defaulting to the highest frequency form of the verb (which in English is usually the bare stem, but in German is usually the 3sg -t form).

The Dual-Factor Model has so far only been used to simulate data on typically developing children, but there is evidence from English-speaking children with DLD that both of the processes implemented in the model are responsible for OI errors in children's speech. For example, Leonard and his colleagues provide evidence that OI errors in English-speaking children with DLD reflect the inappropriate extraction of non-finite structures from more complex structures in the input (e.g., Leonard & Deevy, 2011; Leonard, Fey, Deevy & Bredin-Oja, 2015; Purdy, Leonard, Weber-Fox & Kaganovich, 2014); and Kueser, Leonard and Deevy (2018) provide evidence that OI errors in English-speaking children with DLD reflect a process of defaulting to the bare stem, with children with DLD making significantly more of this type of defaulting error than typically developing children.

For the purposes of this thesis, the Dual-Factor Model makes three predictions about the pattern of verb-marking error in the speech of English- and German-speaking children with DLD and MLU-matched controls. First, since OI errors in English reflect both learning from compound structures in the input and defaulting to the bare stem and OI errors in German reflect the learning of infinitives from compound structures, German- but not English-speaking children will produce OI errors at higher rates in compound finite than in simple finite contexts. Since OI errors are explained in the same way in both typically developing children and children with DLD, this prediction applies to both typically developing children and children with DLD.

Second, since, in the Dual-Factor Model, learning from compound finites is linked to MLU, whereas defaulting to the bare stem is not, English-speaking children with DLD will produce OI errors at higher rates than MLU-matched controls, whereas German-speaking children will not.

Third, since OI errors are assumed to be sensitive to the frequency with which verbs occur as bare forms and infinitives in the input, the Dual-Factor Model predicts input effects on the tendency to produce OI errors with particular verbs in both typically developing children and children with DLD in both English and German.

These predictions, and variants on them, will be tested in the studies that follow. In the case of English, this will be done using an elicited production paradigm based on Räsänen et al. (2014), but extended to include both modal and non-modal elicitation contexts. In the case of German, it will be done by analysing rich naturalistic corpora from a German-speaking child with DLD and a language-matched control, and by using the same elicited production paradigm used to collect the English data.

CHAPTER 4: Testing two different models of the pattern of verb-marking error in English-speaking children with Developmental Language Disorder and language-matched controls

4.0 Rationale for the study reported in Chapter 4

Nativist models of the pattern of verb-marking error in typically developing children and children with DLD assume that this pattern reflects a biologically based maturational difference between the child and the adult grammar. However, recent studies have found significant correlations between English-speaking children’s tendency to produce bare forms in 3sg elicitation contexts and the relative frequency with which particular verbs occur as bare rather than 3sg forms in English child-directed speech (Räsänen et al. (2014) for typically developing children and Kueser, Leonard & Deevy (2018) for children with DLD).

The following chapter reports an elicited production experiment which builds on these findings by adding a modal condition (e.g. ‘Peter can build a castle and Lisa (can build a house)’) and testing the predictions of two different theoretical accounts with respect to the pattern of performance shown by a group of English-speaking children with DLD and a group of MLU-matched controls.

The EOI hypothesis predicts that children with DLD will produce more OI errors than MLU-matched controls in both the modal and the non-modal condition, and that neither group will show an input effect. The Dual-Factor Model predicts that children with DLD will produce more OI errors than the TD group, but only in the simple-finite condition, and that both groups will also show an input effect in this condition.

Although neither account is fully supported by the data, the results show 1) that, in the non-modal condition, the children with DLD produced more OI errors than the typically developing children, whereas in the modal condition this pattern was reversed, and 2) that the children with DLD showed a significant input effect in the non-modal condition, though there was no such effect in the typically developing controls. They are therefore more consistent with the Dual-Factor Model than with the EOI hypothesis.

This study will be submitted to a peer-reviewed journal.

4.1 Introduction

Children with Developmental Language Disorder (DLD) tend to show a particular deficit in the use of verb morphology, with English-speaking children with DLD often failing to produce third person singular (3sg) –s and past tense –ed in 90% of obligatory contexts until very late in development. Generativist accounts of this deficit tend to argue that it reflects a biologically based deficit in the affected children's underlying grammar. Constructivist accounts tend to argue that it reflects a processing deficit that results in faulty processing of the input language. In this paper, we attempt to differentiate between these two possibilities by using a verb-elicitation paradigm to test the predictions of two particular models of the verb-marking deficit in DLD on a group of English-speaking children with DLD and a group of MLU-matched controls. We focus on the children's performance in modal (compound-finite) and non-modal (simple-finite) contexts across a set of verbs that vary in the extent to which they occur in bare versus 3sg present tense form in English child-directed speech.

The Verb-Marking Deficit in DLD

Developmental Language Disorder refers to ‘a significant deficit in language ability that cannot be attributed to hearing loss, low non-verbal intelligence or neurological damage’ (Leonard, 2014: 3). Tomblin, Records, Buckwalter, Zhang, Smith and O’Brien (1997) report that approximately 7% of the preschool-aged population exhibit this kind of developmental profile. These children are often referred to in the literature as children with Specific Language Impairment (SLI). However, in recent years, there has been growing dissatisfaction with this term (Ebbels, 2014), and a new consensus has emerged in favour of the term ‘Developmental Language Disorder’ (Bishop, Snowling, Thompson, Greenhalgh & the CATALISE-2 consortium, 2016; 2017). Developmental Language Disorder is therefore the term that we will use in the present paper. It should be noted that this change in terminology also has implications for precisely how the new term should be used. Thus, in the paper reporting the results of their Delphi study, Bishop et al. (2017) note: “The term, ‘Developmental Language Disorder’ (DLD) was endorsed for use when the language disorder was not associated with a known biomedical aetiology. It was also agreed that (a) presence of risk factors (neurobiological or environmental) does not preclude a diagnosis of DLD, (b) DLD can co-occur with other neurodevelopmental disorders (e.g. ADHD) and (c) DLD does not require a mismatch between verbal and nonverbal ability” (Bishop et al., 2017: 1068).

Children with DLD are not a homogeneous population (Leonard, 2014), and may show deficits in a number of different language domains, including phonology, word learning, morpho-syntax and pragmatics (Kauschke, 2012).

However, they tend to show a particular deficit in the use of verb morphology. Verb-marking errors are a characteristic feature of young children's early multi-word speech. For example, between the ages of 2;0 and 3;0 years, English-speaking children often produce zero-marked verb forms (i.e. bare stems) in 3sg and past tense contexts, see examples (1) to (4) from the Manchester corpus (Theakston, Lieven, Pine & Rowland, 2001) in the CHILDES database (MacWhinney, 2000).

(1) *She go to sleep (Carl, 2;2.15)

(2) *He stand in the corner (Joel, 2;6.26

(3) *I buy them yesterday (Anne, 2;6.04)

(4) *We make this yesterday (Gail, 2:8.13)

However, English-speaking children with DLD produce these kinds of errors for a much more protracted period of development. For example, Rice, Wexler and Hershberger (1998) report significantly lower rates of provision of 3sg present tense –s and past tense –ed in English-speaking children with DLD than both age-matched and MLU-matched controls, with the children with DLD still failing to produce both morphemes in 90% of obligatory contexts as late as seven years of age.

The verb-marking deficit in children with DLD tends to be interpreted in different ways by generativist and constructivist researchers, with generativists taking it to reflect a biologically-based deficit in affected children's underlying grammar, and constructivists taking it to reflect a processing deficit that results in faulty processing of the input language. In the present study, we attempt to differentiate between these two possibilities by testing the predictions of two particular models of the verb-marking deficit in DLD: the Extended Optional

Infinitive hypothesis (Rice, Wexler & Cleave, 1995; Rice & Wexler, 1996), and the Dual-Factor Model (Freudenthal, Pine & Gobet, 2010; Freudenthal, Pine, Jones & Gobet, 2015a). We use a verb-elicitation paradigm to test the predictions of these models with respect to the pattern of error in children with DLD and MLU-matched controls in a) modal (compound-finite) and non-modal (simple-finite) contexts and b) on verbs that vary in the extent to which they occur in bare as opposed to 3sg present tense form in English child-directed speech.

The Extended Optional Infinitive Hypothesis

The Extended Optional Infinitive Hypothesis is built on the assumption that errors involving zero-marked forms in English reflect the optional use of finite and non-finite forms in finite contexts, due to a biologically based maturational difference between the child and the adult grammar. Early analyses of zero-marking errors in English assumed that these errors reflected incomplete knowledge of the target inflection (e.g. Brown, 1973) or the dropping of the relevant inflection due to performance limitations in production (Bloom, 1990; Valian, 1991). However, analyses of verb-marking errors in other languages have revealed that they tend to involve the use of a verb form marked with an infinitival morpheme in a context in which a finite form would be required in the adult language (Ferdinand, 1996; Jordens, 1990; Josefsson, 2002; Poeppel & Wexler, 1993; Wijnen, 1998). This has led to the view that verb-marking errors across languages (including the incorrect use of zero-marked forms in English) reflect the use of non-finite forms in finite contexts. According to the Optional Infinitive (OI) and Extended Optional Infinitive (EOI) hypotheses, these errors, which we will refer to as Optional Infinitive (OI) errors, reflect an underlying difference between the child and adult grammar that extends further up the age and MLU range in children with DLD. More specifically, they reflect the fact that although children have correctly set all the inflectional and clause structure parameters of their language from a very early age, there is a developmental stage (the OI stage), during which they are subject to a Unique Checking Constraint (UCC), which competes with other constraints in the child's grammar to result in the optional use of finite and non-finite forms in finite contexts. The assumption is that the UCC gradually withers away over the course of development, and that it withers away more slowly in the grammars of children with DLD. Children with DLD are therefore subject to an extended OI stage in which they produce OI errors at significantly higher rates than both age-matched and language-matched controls.

The great strength of the EOI hypothesis is that it provides an integrated cross-linguistic account of the pattern of verb-marking error in both typically developing children and children with DLD. Thus, it can explain why children learning obligatory subject languages such as Dutch, English, French and German make OI errors at substantially higher rates than children learning INFL-licensed null subject languages such as Italian and Spanish (Wexler, 1998). It can also explain why other kinds of verb-marking errors (e.g. subject-verb agreement errors such as '*I goes') are rare in both types of language (Harris & Wexler, 1996; Hoekstra & Hyams, 1998). However, it is important to recognise that, because the EOI Hypothesis assumes that the rate at which OI errors occur is determined by a single underlying difference between the child and the adult grammar, the EOI hypothesis predicts a relatively undifferentiated pattern of OI errors in which such errors are equally likely to occur across different finite contexts and across different verbs.

For the purposes of the present study, the EOI hypothesis makes two predictions about the pattern of verb-marking error in the speech of children with DLD and MLU-matched controls. First, since OI errors are assumed to reflect the operation of a single underlying factor that extends higher up the MLU range in children with DLD, the EOI hypothesis predicts that children with DLD will show deficits relative to MLU-matched controls across different (i.e. modal and non-modal) contexts. Second, since OI errors are assumed to reflect a single underlying difference between the child and the adult grammar, as opposed to differences in children's knowledge about particular verbs, the EOI Hypothesis predicts no relation between the rate at which either children with DLD or language-matched controls will produce OI errors on particular verbs and the rate at which those verbs occur in bare as opposed to 3sg present tense form in the input.

The Dual-Factor Model

The Dual-Factor Model is built on the assumption that bare stem errors in English reflect two different processes. The first is the learning of OI errors from modal (compound-finite) structures in the input (e.g. 'She can ride a bike' and 'That could go there'). The second is a process of defaulting to the highest frequency form of the verb (which in English is usually the bare stem), when the correct form of the verb is only weakly represented in the child's system.

The Dual-Factor Model is based on a computational model of the OI stage: MOSAIC, which simulates the developmental patterning of OI errors across several different languages. MOSAIC is a relatively simple distributional learning mechanism, which accepts as input corpora of orthographically transcribed child-directed speech and produces as output strings that have occurred — or are distributionally similar to strings that have occurred — in the language to which the model has been exposed. MOSAIC learns slowly from its input, producing progressively longer utterances as learning proceeds. It can therefore be used to generate output at different MLU-defined points in development. MOSAIC can also learn from the input corpora of children across a range of different languages. It can therefore be used to simulate cross-linguistic variation in the rate at which children produce OI errors.

MOSAIC simulates OI errors because it has a strong utterance-final (and, in later work, a weak utterance-initial and a strong utterance-final) bias in learning. These biases result in the learning of OI errors from modal (compound-finite) utterances: utterances that contain a (finite) modal and an infinitive (e.g. '*That go there' from 'That (could) go there'), though OI errors can also be learned from other longer structures (e.g. '*Mummy do it' from 'Let Mummy do it' or '*Girl jump' from 'We saw the girl jump'). MOSAIC simulates the developmental patterning of OI errors because, as the average length of its utterances increases, these utterances are increasingly likely to include finite modals, with the result that the OI errors in MOSAIC's output are slowly replaced by the longer structures from which they were originally learned.

Initial work using MOSAIC showed that the idea that OI errors were learned from compound-finite structures could explain the cross-linguistic patterning of errors in Dutch, English, German and Spanish (Freudenthal, Pine & Gobet, 2006; Freudenthal, Pine, Aguado-Orea & Gobet, 2007). However, the English simulations in these studies focused only on utterances with overt third person singular subjects. In a later study, Freudenthal and colleagues (2010) showed that, when utterances with missing subjects were included in the analysis, MOSAIC was unable to simulate the very high rates of OI errors in early child English. Freudenthal et al. (2010) therefore argued for a Dual-Factor Model in which MOSAIC's basic learning mechanism was supplemented by an additional defaulting mechanism. This mechanism results in the substitution of the highest frequency form of the verb (which in English tends to be the bare stem) when the correct form of the verb is only weakly represented in the child's system.

According to the Dual-Factor Model, OI errors in modal contexts reflect the learning of bare infinitives from modal (compound-finite) stuctures in the input and reflect the child's limited processing ability (as indexed by MLU). However, (apparent) OI errors in non-modal contexts reflect a process of defaulting to the bare stem. Räsänen, Ambridge and Pine (2014) provide evidence for the plausibility of this additional defaulting mechanism in a verb elicitation study in which the probability of children producing (apparent) OI errors in 3sg present tense contexts was significantly related to the frequency with which the verb occurred in bare stem versus 3sg present tense form in English child-directed speech. Freudenthal, Pine, Jones and Gobet (2015a) show that a version of MOSAIC that combines the model's basic learning mechanism with a frequency-based defaulting mechanism can simulate the very high rate of OI errors in early child English without reducing the model's previously good fit to the rate of OI errors in early child Dutch and Spanish.

The Dual-Factor Model has so far only been used to simulate data on typically developing children. However, there is evidence that both of the mechanisms incorporated in the model are also operative in children with DLD. Thus, Leonard and his colleagues provide evidence that OI errors in English-speaking children with DLD reflect the inappropriate extraction of non-finite subject-verb sequences from more complex structures in the input (e.g., Leonard & Deevy, 2011; Leonard, Fey, Deevy & Bredin-Oja, 2015), and Kueser et al. (2018) replicate Räsänen et al.'s finding that English-speaking children's tendency to produce bare forms in 3sg elicitation contexts is significantly correlated with the relative frequency with which particular verbs occur as bare rather than 3sg presente tense forms in English child-directed speech. The Kueser et al. (2018) study replicates this effect in a group of children with DLD and a group of language-matched controls, with the children with DLD also producing significantly more bare forms in 3sg contexts than the typically developing children.

When taken together, these results suggest that the Dual-Factor Model may be able to account for the pattern of verb-marking error in both typically developing children and children with DLD. However, it is important to recognise that there is a critical difference between the two mechanisms instantiated within the Dual-Factor Model, which has implications for the pattern of error that the model predicts. This is the fact that the original mechanism of learning OI errors from modal structures is closely tied to the child's ability to process and produce progressively longer utterances (as indexed by MLU), whereas the additional mechanism of defaulting to the most frequent form of the verb is not. This means that, if one assumes that the verb-marking deficit in DLD reflects a combination of these factors, the first factor would be expected to result in a higher rate of OI errors in children with DLD in modal (compound-finite) contexts relative to age-matched, but not language-matched, controls, whereas the second factor would be expected to result in a higher rate of OI errors in non-modal (simple-finite) contexts relative to both age-matched and language-matched controls.

For the purposes of the present study, the Dual-Factor Model makes two predictions about the pattern of verb-marking error in the speech of children with DLD and MLU-matched controls. First, since OI errors are assumed to reflect the operation of two different factors, only one of which can be separated from the child's ability to process and produce increasingly longer sentences (as indexed by MLU), the Dual-Factor Model predicts that children with DLD will only show deficits relative to MLU-matched controls in non-modal (simple-finite) contexts. Second, since defaulting errors are assumed to reflect differences in children's knowledge about particular verbs, the Dual-Factor Model predicts a significant correlation between the rate at which both children with DLD and MLU-matched controls will produce defaulting errors (i.e. OI errors in non-modal contexts) on particular verbs and the rate at which those verbs occur as bare as opposed to 3sg present tense forms in English child-directed speech.

The present study

The aim of the present study was to compare two different accounts of OI errors from different theoretical backgrounds. The Extended Optional Infinitive hypothesis (Rice et al., 1995; Rice & Wexler, 1996) assumes that the core deficit in DLD is an extension of the Optional Infinitive stage shown by typically developing children. Hence this account predicts a group difference, whereby children with DLD will show higher rates of OI errors than MLU-matched typically developing (TD) controls regardless of condition (modal/non-modal): Because this account assumes that non-finite forms are a consequence solely of the optionality of tense marking in children's grammars, context (modal/non-modal) should not matter. For the same reason, this account does not predict an effect of the input-bias predictor, for either the DLD or TD groups.

The constructivist Dual-Factor Model (e.g., Freudenthal et al., 2010; 2015a) assumes that (apparent) OI errors have different sources in modal and non-modal contexts. In modal (compound-finite) contexts, such errors reflect omission of the modal auxiliary (e.g., **Lisa [can] paint a flower*), due to limited storage and retrieval capacity, as indexed by MLU. As storage and retrieval capacity increase with development, as indexed by increasing MLU, these errors will disappear. That is, in broad-brush terms, a child at MLU=4 can say only **Lisa paint a flower*, but when she reaches MLU=5, can say *Lisa can paint a flower*. Because (apparent) OI errors in modal contexts are driven essentially by restricted MLU, the Dual-Factor Model predicts that children with DLD will *not* show higher rates of OI errors in modal contexts than younger MLU-matched controls. (They will, of course, show higher rates of OI errors than *age*-matched controls with higher MLUs; a prediction that we do not test in the present study).

In non-modal (simple-finite) contexts, (apparent) OI errors reflect "defaulting" (Räsänen et al., 2014): replacement of the low-frequency simple-finite form (e.g., *paints*) with the much higher frequency "bare" (non-finite/1sg/2sg/1pl/2pl/3pl) form (e.g., *paint*, yielding **Lisa paint a flower*). In previous research (e.g., Freudenthal et al., 2015a), the Dual-Factor Model has been applied only to typically developing children. Extending this model to account for the well-established finding (Rice et al., 1995; Rice et al., 1998) that English-speaking children with DLD produce more OI errors than MLU-matched controls requires the assumption that this effect is driven by a higher-rate of defaulting in non-modal contexts (since, as we have just seen, the account predicts that, in modal contexts, children with DLD will not produce more OI errors than MLU-matched controls). In other words, the assumption is that children with DLD "are even more influenced by the input than younger typically developing children matched for MLU" (Kueser et al., 2018; see also Leonard et al., 2015).

In summary, then, the Dual-Factor Model predicts an interaction such that children with DLD will produce OI errors at higher rates than language-matched controls, but only in the non-modal (simple-finite) condition, and not the modal (compound-finite) condition (or, at least, to a considerably greater extent in the non-modal than the modal condition). Because the Dual-Factor Model assumes input-based learning, it also predicts (for DLD and TD children alike) an input-frequency effect for the non-modal (simple-finite) condition only. That is, we expect to replicate, for both DLD children and MLU-matched controls, the findings of Räsänen et al. (2014) and Kueser et al. (2018) of a correlation between verbs' bias to appear with/without 3sg *-s* in the input and children's tendency to produce verbs with/without 3sg *-s* in non-modal (simple finite) contexts, where (apparent) OI errors are held to reflect defaulting to the more frequent bare form. Note that the Dual-Factor Model predicts no such input effect in modal contexts, where such errors are held to reflect simple modal omission, and not defaulting to a more frequent form in the input.

4.2 Methods

Ethics statement

This study was approved by the University of Liverpool Ethics Committee. Informed written consent was obtained from the schools and caregivers, and the children gave verbal consent.

Participants

An initial sample of 102 children were tested and assigned to either the group of DLD children (final N=25) or to the group of younger MLU-matched typically-developing (TD) controls (final N=50), with non-qualifying children, according to the criteria described below, excluded (N=27). See Appendix A for an overview of the exclusion process of tested participants. 99 children were recruited from 28 nurseries and primary schools in Liverpool and the Merseyside area. 3 children were recruited through the database from the Liverpool Language Lab. All children were monolingual speakers of British English and had no history of hearing problems and no other disorders that could have caused problems with language (e.g. Down Syndrome, ADHD, neurological dysfunction).

Group (DLD/TD) was assigned using three subtests from the Clinical Evaluation of Language Fundamentals - Preschool 2 UK (CELF Preschool-2) (Wiig, Secord, & Semel, 2004) that, together, cover the areas of vocabulary and grammar (both comprehension and production): sentence structure, word structure and expressive vocabulary. The three subtests of the CELF were scaled, summed and transformed into a standardized score. Only children with a scaled score of 18 or lower, corresponding to 1.5 SD below the mean (as in, e.g., Kueser et al., 2018) were included in the DLD group. We also administered the British Picture Vocabulary Scale Third Edition (BPVS3) (Dunn, Dunn, Whetton, Burley, Styles, & Sewell, 2009), simply as an additional measure of vocabulary to use as a control predictor in the statistical analysis and not, since a CELF vocabulary measure is already included, to assign children to groups. Because the MLU-matched TD control group were too young for the published CELF norms to be applicable, we instead adopted our own criterion: In order to be included in this group, children had to score no lower than 1.33 SD below the mean score for the group. In addition to children excluded according to these DLD/TD criteria, one child was excluded because she gave no valid responses in the main experiment.

In order to ensure that the DLD and TD groups were broadly matched for non-verbal IQ, we also administered the non-verbal part of the *Kaufman Assessment Battery for Children Second Edition* (KABC-II; Kaufman & Kaufman, 2015). Even though the KABC-II is not standardized for the younger typically developing age group, the TD and DLD groups had very similar means (average IQ 91, SD=13.2 vs. 98, SD=16.4). Following recent recommendations that “children with DLD may have a low level of non-verbal ability” (Bishop, Snowling, Thompson & Greenhalgh, 2017: 1072), we did not exclude children from the DLD group on the basis of their IQ scores.

The final DLD group consisted of 25 children (8 females) aged 3;0 to 4;10 (M = 3;7, SD = 5.4 months), with a Mean Length of Utterance (MLU) of 2.01 (SD = 0.49). The final MLU-matched control group consisted of 50 children (21 females) with MLU of 2.26 (SD = 0.69). MLU scores (in words) were derived from a spontaneous language sample (as described below). Three children from the DLD group and 8 children from the TD group did not take part in this session; therefore, the mean MLU (across all children) was used for these children in the analysis.

Design and materials

The study consisted of a verb elicitation experiment with two different conditions: non-modal (simple-finite; e.g., *Lisa paints a flower*) and modal (compound-finite; e.g., *Lisa can paint a flower*). The dependent variable was the number of correct verb forms (either *3sg -s* or *modal* + *infinitive,* depending on condition) versus OI errors (with all other responses excluded as missing data). In each condition 30 prompt sentences with different verbs (see Appendix B) were presented alongside pictures of two children, using a laptop computer. Following Räsänen et al. (2014) and Kueser et al. (2018), verbs were selected on the basis that, in the input portion of the Manchester corpus (Theakston et al., 2001), they were strongly biased to occur either with or without 3sg -s (the bias measure is described below). Verbs were also chosen to be high frequency, unambiguous and easy to illustrate in pictures (Figure 1). Both conditions had the same set of 30 verbs (e.g., *Lisa can paint a flower; Lisa paints a flower*), which were presented in randomized order.

Before the experiment started, the researcher introduced a story featuring two children, Lisa and Peter, to the participant. These warm-up sentences also served to introduce the two conditions (e.g., *Every day Peter does something vs. Every day Peter can do something*). Then two practice trials followed, in which, if necessary, the researcher prompted the child and/or gave the correct answer for the child to repeat.

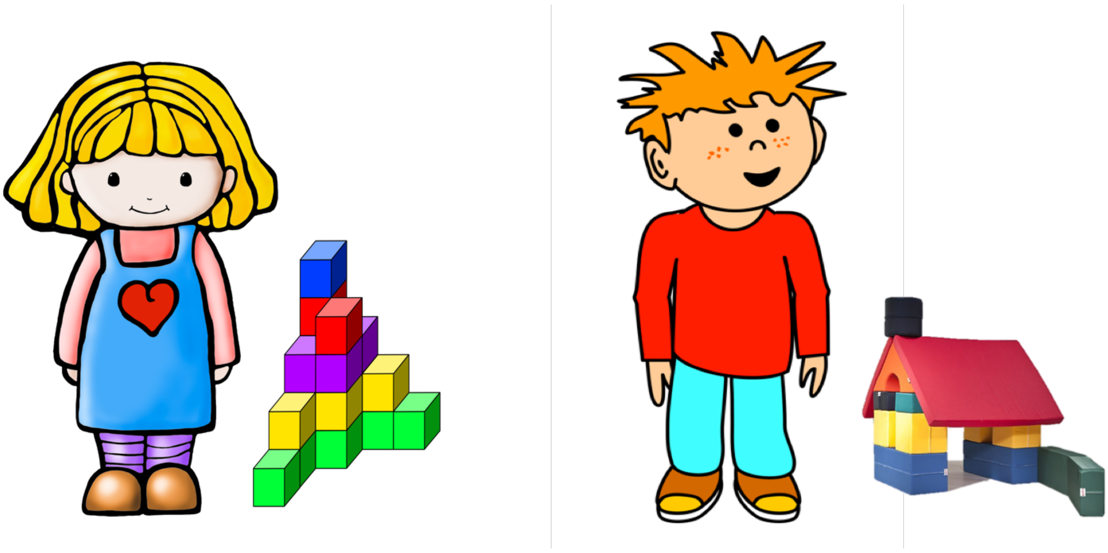

Figure 1: Example context for build taken from the elicitation experiment. (a "Lisa builds a tower. Peter…" b "Lisa can a tower build-INF. Peter…")

Each of the 30 trials, as well as the two practice trials, consisted of a prompt sentence for children to complete with the help of the illustrations on the laptop screen (e.g. non-modal condition: *Lisa builds a tower. Peter…*; modal condition: *Lisa can build a tower. Peter…*). Every sentence started with a two-syllable word, which was always the name of one of the characters (*Lisa or Peter*). In every target clause, the verb was followed by a two- or three-syllable phrase (e.g., *a cake; a tower*), except for two phrases with four syllables ([*catches] a butterfly, [watches] Bob the builder*). Wherever possible, this phrase began with a vowel (usually the word *a*), in order to allow us to identify easily whether or not children produced the 3sg *-s* ending in the non-modal (simple-finite) condition. The order in which each condition was presented to the children was random.

Procedure

Each child was tested individually in a quiet setting, with each session lasting approximately 30-45 minutes, depending on the child. Testing was divided into two sessions on different days. All sessions were audio recorded with a dictaphone and additionally with Audacity (running in the background of the laptop used for the experiment). During the recordings the researcher took care not to use the child's name.

On Day 1, children completed the BPVS, the sentence structure and word structure tests from the CELF, the first two subtests from the K-ABC-II and 30 trials from the main study. On Day 2, children completed the expressive vocabulary test from the CELF, the remaining two subtests fron the K-ABC-II and a further 30 trials from the main study. Finally, the researcher introduced a standard set of toys (a wooden farmhouse and animals) to use for play and interaction, while collecting the spontaneous speech sample for calculating MLU. The researcher described the ongoing play, and encouraged the child to do the same, for 15-20 minutes.

Transcription, scoring and reliability

The play sessions were recorded and transcribed offline in CHAT format (MacWhinney, 2000), and MLU was calculated using CLAN (MacWhinney, 2000). Responses from the experiment were transcribed during the testing and checked afterwards using the audio recordings. Responses were coded as (1) correct, (2) OI – Optional Infinitive error or (3) unscorable, as described below.

(1) Correct (N=938): The child produced (a) 3rd person singular *-s* with the target verb in the non-modal (simple-finite) condition or (b) the modal *can* and the target verb in non-finite (bare) form in the modal (compound-finite)

condition (e.g., *Lisa paints a flower; Lisa can paint a flower*). The OBJECT (e.g., a flower) did not have to be correctly produced for the utterance to be scored as correct (or, as an OI error)

(2) OI – Optional Infinitive error (N=1236): The child produced the target verb in non-finite (bare) form, in either condition (e.g., *Lisa paint a flower*).

(3) Unscorable (N=2326): The child produced (a) no response or an unintelligible response, (b) a non-target verb, (c) the target verb with the modal *can* in the simple-finite condition, (d) the target verb with 3rd person singular -*s* in the modal condition, (e) only the modal *can*, or (f) some other response like a non-target verb with incomplete inflection or target verb with wrong tense and incomplete inflection. See Appendix C for an analysis of error rates. Although the proportion of unscorable responses (52%) is relatively high, many of these responses were pragmatically appropriate in the context e.g. "Lisa plays a guitar. Peter…" answer from the child: "a piano". The proportion of unscorable responses is not unexpected given the experimental design, in which children are free to produce any response, and is similar to that observed in comparable studies (e.g., Tatsumi, Ambridge & Pine, 2018; Räsänen et al., 2014; Kueser et al., 2018).

In order to calculate reliabilities, 10% of the responses from the experiment were transcribed independently by a native English speaker blind to the hypotheses under investigation. Inter-rater reliability was high at 87% agreement (Cohen's Kappa = .8). Any disagreements regarding the presence of a 3rd person singular -s were subjected to re-listening until agreement was reached.

Analyses

Predictor variables were condition (non-modal (simple-finite) / modal (compound-finite)), group (DLD/ TD), MLU, BPVS (both as control predictors) and a predictor reflecting the relative frequency of each verb with and without 3sg -s marking in the child-directed speech sample of the Manchester corpus (Theakston et al., 2001). As in previous studies, we used a chi-square statistic that reflects the extent to which, relative to other verbs in the corpus, each verb appears with and without 3sg -s marking (see, e.g., Tatsumi et al., 2018 for details). The chi-square values were natural-log transformed (ln(1 + n)) and polarity (+/–) set to indicate whether a verb is biased towards finite or non-finite form, as is standard for this type of measure (see, e.g., Gries, 2015).

Although the measure is not based on the individual participants' input (which is not available), our assumption is that it constitutes a reasonable approximation to the general by-verb distribution of finite versus non-finite forms in child-directed speech. The finding that participants' behaviour is predicted by the frequency of items in a corpus of data that does not represent their individual input is well established for both adults and children (e.g., Bannard & Matthews, 2008); see Ambridge, Kidd, Rowland and Theakston (2015) for a review.

4.3 Results

Figure 2 summarizes the responses for the DLD and MLU-matched TD control group. Visual inspection of this figure suggests possible support for the prediction of the Extended Optional Infinitive hypothesis that the DLD group will show a higher overall rate of OI errors than the TD group; but also for the prediction of the Dual-Factor Model that this effect will only be observed (or, at least, will be significantly greater) in the non-modal condition. It also suggests possible support for the prediction of the Dual-Factor Model that a significant effect of the chi-square input-bias measure will be observed in the non-modal condition only; though, somewhat unexpectedly, this effect seems to be driven almost entirely by the DLD group.

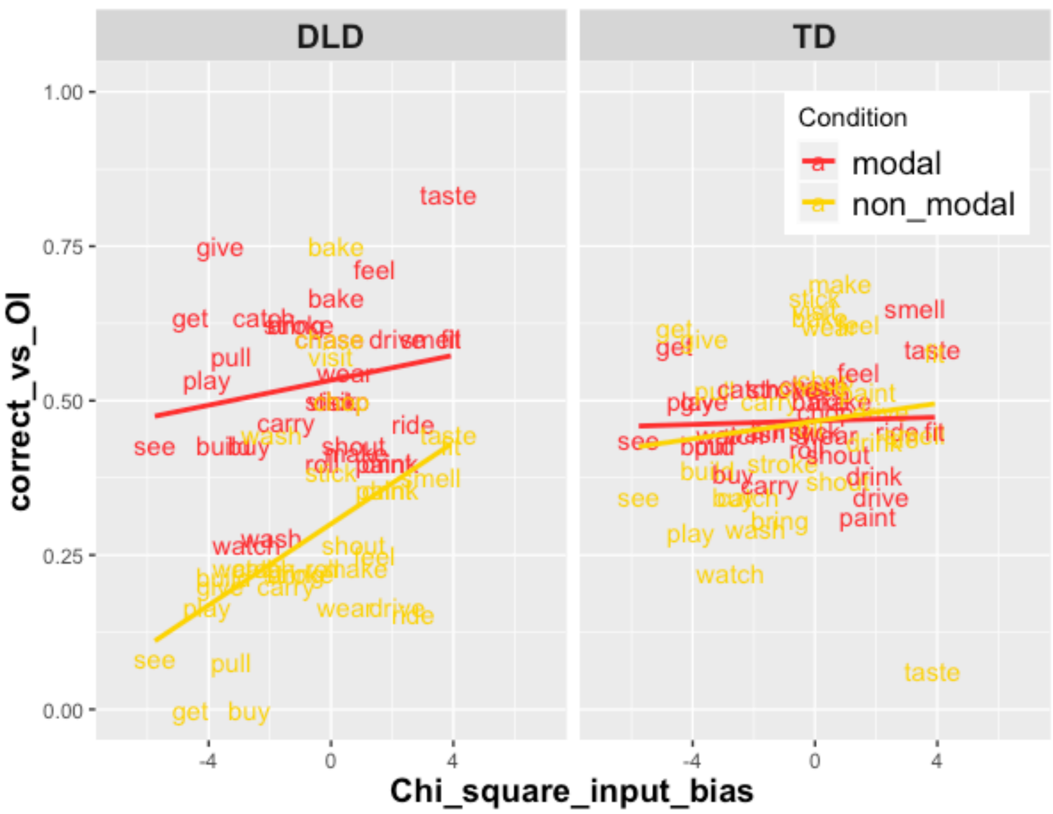

Figure 2: Mean proportion of correct responses (vs OI errors) for the DLD and TD groups as a function of condition (modal/nonmodal) and the chi-square input-bias predictor (higher values indicate a greater proportion of occurrences with 3sg -*s*)

The data were analysed in RStudio (version 1.1.463; R version 3.5.3, R Core Team, 2018). As the dependent variable was binary (correct/OI, with other responses treated as missing data), results were analysed as logistic regression using the glmer function of the lme4 package (version 1.1-17, Bates, Maechler, Bolker & Walker, 2015) with the bobyqa optimizer. Predictor variables were MLU, vocabulary (BPVS raw scores), the chi-square input-bias predictor, group and condition. The model included random intercepts for verb (item) and participant and a by-participant random slope of the chi-square input-bias predictor (e.g., Barr, Levy, Scheepers, & Tily, 2013). The introduction of any further random slopes caused convergence failure.

Since all models were binomial, we report *p* values calculated on the basis of the z distribution (output by default from the glmer function of lme4). None of the other popular methods for calculating *p* values (see Luke, 2017 for details) could be used in this case: (1) MCMC sampling is not implemented for models with random slopes. (2) Methods that rely on comparing nested models (likelihood ratio test; Kenward–Roger approximation) do not allow for the removal of a simple main effect while retaining interaction terms for that variable. (3) The Satterthwaite degrees of freedom method (e.g., lmerTest package; Kuznetsova, Brockhoff & Christensen, 2017) is based on the multivariate normal distribution, and so is not applicable to binomial models. (4) Parametric bootstrapping (found by Luke, 2017, to be the most conservative) is not compatible with the bobyqa optimizer, without which, even a model with random intercepts but no random slopes failed to converge. In any case, there is no reason to believe that the method we used is anticonservative: Since, for binomial models, lme4 outputs *z* values directly, *p* values can legitimately be taken from the *z* distribution, without the potentially problematic step – required for models with a continuous dependent variable – of treating the Wald *t* value as if it were a *z* value (the *t* and *z* distributions are identical only with an infinite sample size).

We first built a full model including all three predictors of interest, group (DLD coded as 0 / TD coded as 1), condition (modal coded as 0 / non-modal coded as 1), and the chi-square input-bias predictor, as simple main effects and in all interactions, and the control predictors, MLU and vocabulary (BPVS score), as simple main effects only.

Table 2: Mixed effects model for all English data

Parameter	**M**	**SE**	**CI_low**	**CI_high**	**z**	**p**
(Intercept)	-4.63	0.93	-6.45	-2.81	-4.99	< 0.001
MLU	**1.43**	**0.34**	**0.76**	**2.11**	**4.16**	**< 0.001**
Vocabulary	**0.04**	**0.02**	**0**	**0.08**	**2.05**	**0.041**
Input bias	0.03	0.06	-0.08	0.15	0.56	0.578
Group	-0.74	0.44	-1.6	0.12	-1.68	0.094
Condition	**-1.1**	**0.22**	**-1.52**	**-0.67**	**-5.06**	**< 0.001**
Input bias x group	-0.02	0.07	-0.15	0.11	-0.3	0.766
Input bias x condition	**0.21**	**0.09**	**0.03**	**0.38**	**2.34**	**0.019**
Group x condition	**1.21**	**0.26**	**0.7**	**1.71**	**4.7**	**< 0.001**
Input bias x group x condition	-0.15	0.1	-0.35	0.05	-1.47	0.142

The model (see Table 2) revealed significant simple main effects for the control predictors of MLU and vocabulary (BPVS), which highlights the importance of including these control predictors in the analysis. With regard to the theoretical predictions under investigation, the analysis did not provide support (p=0.09) for the prediction of the Extended Optional Infinitive account that, collapsing across condition (modal/non-modal), the DLD group will produce a lower proportion of correct forms (M=0.38, SD=0.50), and hence a higher-rate of OI errors, than the TD group (M=0.45, SD=0.49). However, given that this is a between-subjects comparison and a relatively small (if not untypical) sample size, this finding certainly cannot be taken as evidence for the null hypothesis of no difference between the groups, or as evidence against the Extended Optional Infinitive account.

The observed simple main effect of condition ($p<0.001$), such that, collapsing across group (DLD/TD), children produced a higher proportion of correct forms in modal (M=0.47, SD=0.50) than non-modal contexts (M =0.40, SD =0.49) was not specifically predicted by either the Extended Optional Infinitive or Dual-Factor account. However, the observed interaction ($p<0.001$) of group (DLD/TD) by condition (modal/non-modal) is consistent in principle with the prediction of the Dual-Factor account that the DLD group will produce higher rates of OI errors than the MLU-matched TD control group in the non-modal condition only, pending more detailed investigation of the interaction below. Similarly, the observed significant interaction (p=0.02) of input-bias by condition (modal/ non-modal) is consistent, in principle, with the prediction of the Dual-Factor account that, collapsing across group (DLD/TD), children will show an input effect in the non-modal condition only; again, pending more detailed investigation of this interaction.

Submodels by condition

In order to better understand the interactions described above, we ran separate models for the modal (compound-finite, Table 3a) and non-modal (simple-finite, Table 3b) conditions. The models were the same as the all-participants model above, except for the exclusion of condition (modal/non-modal) and its associated interactions.

Table 3a: Mixed effects model for modal condition

Parameter	M	SE	CI_low	CI_high	z	p
(Intercept)	-8.81	2.07	-12.87	-4.76	-4.26	< 0.001
MLU	**2.46**	**0.74**	**1.01**	**3.92**	**3.32**	**< 0.001**
Vocabulary	0.08	0.04	-0.01	0.16	1.76	0.079
Input bias	0.02	0.08	-0.14	0.19	0.26	0.794
Group	-0.93	0.9	-2.69	0.83	-1.03	0.301
Input bias x group	-0.02	0.09	-0.2	0.16	-0.19	0.848

Table 3b: Mixed effects model for non-modal condition

Parameter	M	SE	CI_low	CI_high	z	p
(Intercept)	-4.1	0.88	-5.83	-2.37	-4.65	< 0.001
MLU	**1.27**	**0.32**	**0.65**	**1.89**	**3.99**	**< 0.001**
Vocabulary	0	0.02	-0.04	0.04	0.14	0.887
Input bias	**0.24**	**0.08**	**0.09**	**0.39**	**3.12**	**< 0.001**
Group	0.43	0.4	-0.35	1.21	1.08	0.279
Input bias x group	**-0.17**	**0.08**	**-0.32**	**-0.02**	**-2.23**	**0.026**

As predicted by the Dual-Factor account, this analysis revealed a significant simple main effect of the chi-square input-bias predictor for the non-modal (simple-finite) condition (p=0.002), but not the modal (compound-finite) condition (p=0.8), echoing the interaction observed in the main analysis (p=0.02). Recall that the Dual-Factor account predicts this pattern as it is only in the non-modal condition that (apparent) OI errors reflect input-frequency-based "defaulting", rather than simple modal omission. That said, the observed significant interaction of the input-bias predictor by group (DLD/TD) raises the possibility that, inconsistent with the predictions of this account (and the findings of Räsänen et al., 2014, and Kueser et al., 2018), this effect may not hold for both the DLD and TD groups separately.

Finally, this analysis yielded no support for the prediction of the Dual-Factor Model that the DLD group will produce higher rates of OI errors than the MLU-matched TD group in the non-modal condition only. Again, however, as a between-subjects comparison with relatively small sample size, this null finding should not be taken as positive support against the prediction under investigation, particularly as the significant interaction observed in the main analysis demonstrates that the effect of group DLD/TD *was* significantly larger for the non-modal than modal condition: In the non-modal condition, the TD group (M=0.45, SD=0.50) numerically outperformed the DLD group (M=0.27, SD=0.44); in the modal condition, the TD group (M=0.46, SD=0.50) and DLD group (M=0.49, SD=0.50) showed very similar performance (indeed, the means were in the opposite direction).

Submodels by group in the non-modal (simple-finite) condition

In order to investigate the significant interaction of the input-bias predictor by group (DLD/TD) observed in the non-modal condition, we ran separate models by group for the non-modal (simple-finite) condition only. Neither the model for the DLD nor the TD children would converge with random slopes, or with random intercepts for both participants and items (verbs); therefore, the only random effect included was a random intercept for participant. These models confirmed that, as suggested by the previous analysis and visual inspection of Figure 2, an effect of input-bias was observed for the DLD group (Table 4a) but not the TD group (Table 4b).

Table 4a: Mixed effects model for DLD children in non-modal condition

Parameter	M	SE	CI_low	CI_high	z	p
(Intercept)	-1.96	1.67	-5.23	1.31	-1.17	0.24
MLU	0.2	0.7	-1.17	1.58	0.29	0.773
Vocabulary	0.01	0.03	-0.05	0.07	0.18	0.856
Input bias	**0.21**	**0.06**	**0.09**	**0.33**	**3.31**	**< 0.001**

Table 4b: Mixed effects model for TD children in non-modal condition

Parameter	M	SE	CI_low	CI_high	z	p
(Intercept)	-4.16	1.01	-6.14	-2.17	-4.1	< 0.001
MLU	1.5	0.34	0.83	2.17	4.38	< 0.001
Vocabulary	0	0.03	-0.05	0.06	0.09	0.926
Input bias	0.06	0.04	-0.01	0.13	1.61	0.108

This pattern is at odds with both the predictions of the Dual-Factor Model and with previous studies that have found an input effect of this type for both TD (Räsänen et al., 2014) and DLD groups (Kueser et al., 2018). Potential reasons for this anomaly will be considered in the Discussion.

To summarize, the present study was not able to demonstrate support for the prediction of the Extended Optional Infinitive hypothesis (Rice et al., 1995), that the DLD group will produce more OI errors than the TD group across conditions (modal/non-modal). That said, with the means in the predicted direction, our likely-highly-underpowered study cannot be taken as strong evidence against this prediction either. More problematic for the Extended Optional Infinitive hypothesis, which does not predict any input-frequency effects, was the finding that, as predicted by the Dual-Factor Model (Freudenthal et al., 2015a), children showed an input-bias effect in the non-modal condition only (though the unexplained finding that this effect was driven almost entirely by the DLD group is not predicted by the Dual-Factor Model). Also problematic for the Extended Optional Infinitive hypothesis was the finding that, as predicted by the Dual-Factor Model, the extent to which the TD group outperformed the DLD group was significantly greater for the non-modal than modal condition (though, again, contrary to the predictions of the Dual-Factor Model, the TD>DLD comparison in the non-modal condition was not significant, perhaps due to low power).

4.4 Discussion

The aim of this study was to use experimental data from children with DLD and MLU-matched TD controls to compare two different models of the verb-marking deficit in DLD: the Extended Optional Infinitive hypothesis and the Dual-Factor Model. The study comprised a verb elicitation experiment designed to elicit *3sg* verb forms in simple-finite (e.g., *Lisa paints*…) and compound-finite contexts (e.g., *Lisa can paint*).

In fact, neither the EOI nor the Dual-Factor Model enjoyed unequivocal support. With respect to the EOI hypothesis, the present study did not provide evidence for the prediction that the DLD group will produce more OI errors than the TD group across conditions (modal/non-modal). However, given that the means were in the predicted direction and the sample size relatively small, it remains possible that this effect would have been observed in a better-powered study. A more definitive test of this prediction must await future studies, which could use the effect size observed in the present study as the basis for a power calculation that would ensure a well-powered design.

The Dual-Factor Model arguably enjoys better support in that, as predicted, an input-bias effect was observed in the simple-finite (non-modal) condition. At first glance, this pattern seems consistent with the findings of Räsänen et al. (2014). However, the finding that this effect was driven almost entirely by the DLD group is at odds with the findings of both Räsänen et al. (2014), who tested TD children only, and Kueser et al. (2018) who found an input effect across both the TD and DLD groups. It is also at odds with the predictions of the Dual-Factor Model, under which one would expect to see an input effect in both groups. Inspection of Figure 2 suggests that the reason that the DLD group, but not the TD group, showed an input effect in the present study lies with the lower degree of by-verb variance shown by the latter group. This does not reflect a simple ceiling or floor effect per se. Rather, the TD group tend to produce OI errors at a rate of around 60% regardless of the identity of the verb, while the DLD group tend to produce OI errors at rates of anything between 10% and 50%, depending on the verb.

One possible explanation is that this pattern is driven mainly by the younger children in the TD group – the youngest of whom were just 25 months old – who tended to produce high rates of OI errors across the board (perhaps due in part to difficulty concentrating). Additionally, this pattern could have been driven mainly by a low-SES (socio-economic status) subgroup of TD children who, again, might be expected to produce high rates of OI errors regardless of the verb. Although we were not able to collect SES data, other studies have shown that early language development is associated with SES (McGillion, Pine, Herbert & Matthews, 2017), and the recruiting area, Liverpool, has a lower SES than most other UK cities (Noble, S., McLennan, D., Noble, M., Plunkett, E., Gutacker, N., Silk, M. & Wright, G., 2019). Future studies should investigate TD children older than 30 months and control for SES (e.g., with a questionnaire for parents).

Nevertheless, even if – perhaps for the reasons set out above – the present study underestimates the input-sensitivity of the TD group, it raises the intriguing possibility that children with DLD are more sensitive to the input than TD children (e.g., Leonard et al., 2015). Although at first glance, this claim appears paradoxical – one would assume that greater sensitivity to the input should result in *better* rather than *worse* language acquisition – it can potentially explain the present findings: The assumption here is that this greater sensitivity manifests itself in an over-reliance on strings that have been rote-learned from the input (e.g., *girl jump*) without an appreciation of the wider linguistic and communicative context (e.g., *We saw the girl jump*)

Another finding consistent with the Dual-Factor Model is that the TD group outperformed the DLD group to a significantly greater extent in the non-modal (simple-finite) condition than the modal condition. Recall that this prediction follows from the Dual-Factor Model on the assumption that, compared with TD children, children with DLD are more influenced by input strings (in a way that ignores the wider context) and so will be more prone to defaulting effects (which, under the Dual-Factor Model, are the primary source of OI errors in simple-finite contexts). Again, however, this support for the Dual-Factor Model is somewhat undermined by an unexpected wrinkle: Although the predicted interaction revealed that the TD group outperformed the DLD group to a significantly greater extent in the non-modal than modal condition, the extent to which the TD group outperformed the DLD group within the non-modal condition itself was not significant. Again, this may reflect a certain level of “underperformance” by the TD group, perhaps linked to their low age and/or SES, or a simple lack of power.

In addition to addressing the relatively poor performance of the present TD group, future research should adapt the paradigm used here for research in other languages. In fact, English, the language investigated in the present study is, in many respects, rather atypical as a verb-inflecting language, because of its impoverished morphology. Indeed, the Dual-Factor Model, in its computational instantiations, already makes predictions regarding the patterning of OI errors across languages (Freudenthal et al., 2015a). Extending these predictions to encompass potential differences between TD children and those with DLD, and then testing them experimentally, would seem to be the next logical step.

In summary, the main conclusion that can be drawn from the present study – although it must remain tentative following a better-powered replication with a better-performing TD group – is that, as suggested by Leonard and colleagues (Leonard & Deevy, 2011; Leonard et al., 2015; Kueser et al., 2018), DLD seems to reflect, at least in part, an over-reliance on strings that children have rote learned from the input, without an appreciation of their wider context. This assumption can potentially explain the finding that when producing simple finites, the DLD group were both (a) impaired overall relative to an MLU-matched TD group (because they are more likely to default to the high-frequency bare stem) and (b) more sensitive to the relative input frequency of the verb in 3sg *-s* vs bare form. It can also potentially explain the insight underlying the EOI hypothesis — that children with DLD show higher overall rates of OI errors than not just age-matched but also MLU-matched TD controls.

The conclusion that DLD is characterized by an over-reliance on the input, if confirmed by subsequent studies, could have clinical importance. For example, one implication is that interventions should focus not on training particular verb forms in isolation (e.g., *She jumps*), but in providing evidence regarding the contrasting contexts in which particular surface strings are (in-) appropriate (e.g., *Every day the girl jumps* vs *Yesterday we saw the girl jump*) – see Fey, Leonard, Bredin-Oja and Deevy (2017) for an intervention study along these lines.

In conclusion, whether or not we are correct in our speculation that DLD is characterized by an over-reliance on rote-learned input strings, the present study has advanced our knowledge of the condition by showing – albeit tentatively – that, in simple-finite contexts, children with DLD are both particularly prone to OI errors in general, and particularly influenced by the relative frequency of bare (vs 3sg -s) form in the input; findings that any successful account of DLD will need to explain.

CHAPTER 5: Testing the (Extended) Optional Infinitive Hypothesis in German: An analysis of rich corpus data from a child with Developmental Language Disorder

5.0 Rationale for the study reported in Chapter 5

The results of the study reported in the previous chapter provided some support for the Dual-Factor Model as an account of the pattern of verb-marking error in English-speaking children with DLD. However, both the Dual-Factor Model and the EOI hypothesis make predictions about the pattern of verb-marking error in children with DLD across languages. The study reported in the following chapter therefore seeks to test the predictions of these models in another OI language: German, using rich corpus data from a German-speaking child with DLD (Bastian) and a language-matched control child (Leo).

The EOI hypothesis predicts that there will be an extended period in which the German-speaking child with DLD produces OI errors at higher rates than the MLU-matched control, but that neither child will make subject-verb agreement or verb-positioning errors in their speech or show input effects on the rate at which OI errors are made with particular verbs. The Dual-Factor Model predicts no MLU-matching effect, but predicts defaulting and verb-positiong errors, particularly in the child with DLD, and predicts input effects on the rate of OI errors in both children.

While the results reveal a short period during which Bastian produced OI errors at significantly higher rates than Leo at equivalent MLUs, they also show that Bastian made subject-verb agreement and verb-positioning errors at higher rates than the EOI hypothesis would predict, and that there was a significant correlation for both Bastian and Leo between the rate at which they made OI errors with particular verbs and the rate at which those verb occurred in infinitive versus finite form in their input. These results are difficult to reconcile with the EOI Hypothesis and are broadly consistent with the Dual-Factor Model.

This chapter has been accepted for publication in the book *Driving Forces in Language Development* edited by Peter Jordens and Dagmar Bittner.

5.1 Introduction

The aim of this chapter is to use rich corpus data from a German-speaking child with Developmental Language Disorder (DLD) and a typically developing language-matched control to compare different models of the verb-marking deficit in DLD. Tomblin, Records, Buckwalter, Zhang, Smith and O'Brien (1997) report that approximately 7% of the preschool-aged population exhibits a significant deficit in language ability without showing other weaknesses that would lead to a diagnosis such as hearing impairment, intellectual disability, neurological impairment, or autism spectrum disorder. Children with this developmental profile are often referred to in the research literature as children with Specific Language Impairment (SLI). However, in recent years, the term Specific Language Impairment has becoming increasingly controversial (Ebbels, 2014), and a new consensus has emerged that Developmental Language Disorder (DLD) is a more appropriate term to describe these children's problems (Bishop, Snowling, Thompson, Greenhalgh & the CATALISE-2 consortium, 2017). Developmental Language

Disorder is therefore the term that we will use in the present chapter. Children with DLD constitute a heterogeneous population (Leonard, 2014). They may show a delayed start in language learning, slow language development and deficits in a variety of language domains, including phonology, word learning, morpho-syntax and pragmatics (Kauschke, 2012). In this chapter, we will focus on morpho-syntax, and, in particular, on the deficit that children with DLD show in the acquisition of inflectional verb morphology.

Difficulties in verb-marking are a characteristic feature of young children's early multi-word speech. For example, between the ages of 2;0 and 3;0 years, English-speaking children often produce zero-marked verb forms in contexts that require a third person singular present tense form, see examples (1) to (3) produced by Anne from the Manchester corpus (Theakston, Lieven, Pine & Rowland, 2001).

(1) *Anne like strawberries.

(2) *That one go there.

(3) *Dolly go sleep.

Children with DLD show a particular deficit in this area. They produce bare forms for a much more protracted period of development. For example, Rice, Wexler and Hershberger (1998) report significantly higher rates of infinitives in English-speaking children with DLD than both age-matched and MLU-matched controls, with the children with DLD still failing to produce 3sg present tense –s in 90% of obligatory contexts as late as seven years of age.

Early analyses of these kinds of utterances assumed that they reflect incomplete knowledge of the target inflectional system (e.g. Brown, 1973), or that they were a matter of dropping the relevant inflection due to production limitations (Bloom, 1990; Valian, 1991). However, in languages other than English, the equivalents of these utterances often include verb forms marked with a particular infinitival morpheme, and hence cannot be explained in terms of inflection drop. In the following examples (4) to (6) below, the verb is marked with the infinitival morphemes *–ir* (French (Pierce, 1992)), *-en* (German (Poeppel & Wexler,1993)) and *–a* (Swedish (Josefsson, 2002)).

(4) *Pas la poupée dormir

Not the dolly sleep-INF

The dolly not sleep

(5) *Thorsten Ball haben

Thorsten ball have-INF

Thorsten have ball

(6) *Pappa bära den

Daddy carry-INF it

Daddy carry it

These utterances clearly reflect the use of an infinitive when a finite verb form would be expected. This has led to the view that problems in verb marking across languages (including the incorrect use of zero-marked forms in English) reflect the use of non-finite forms when a finite form would be required by the adult grammar[1]. Since these utterances tend to occur during a stage in which the child is also producing correct finite forms, they are often referred to in the literature as Optional Infinitives (OI's) (Wexler, 1994).

[1] In this chapter the terms finite and non-finite will be used in the traditional way to refer to morphological finiteness.

A number of theories have been proposed to account for the occurrence of OI's in children's speech (e.g. Rizzi, 1993/1994, Hyams, 1996; Hoekstra & Hyams, 1998). The most influential is Wexler's Optional Infinitive (OI) hypothesis (Poeppel & Wexler, 1993, Wexler, 1994; 1998). According to this hypothesis, by the time children begin to produce multi-word speech, they have already set all the inflectional and phrase structure parameters of their language. However, their grammars allow the optional use of non-finite forms in utterances in which a finite form would be required by the adult grammar. The theory also explains why children's use of finite and non-finite forms is correct with respect to target-like clause structure.

In German, for example, finite forms are inflected for person, number and tense. They are also subject to the so-called verb-second rule, which means that, in declarative sentences, the finite verb must appear in second position (see examples (7) to (9)). Finite verbs in German typically occur after the subject and before the object (7). However, German has relatively flexible word order and also allows adverbials (8) and objects (9) to take first position. In such cases, the finite verb still takes second position, immediately following the adverbial or object, with the subject usually placed behind.

(7) Die Mutter kauft das Brot.

The mother buys the bread.

(8) Am Dienstag kauft die Mutter das Brot.

On Tuesday bought the mother the bread

On Tuesday the mother bought the bread.

(9) Das Brot kauft die Mutter.

The bread bought the mother

The mother bought the bread.

Non-finite forms, on the other hand, take utterance-final position, with the modal (10) or auxiliary (11) taking second position and other constituents intervening between the modal or auxiliary and the non-finite lexical verb.

(10) Die Mutter kann das Brot kaufen.

The mother can the bread buy

The mother can buy the bread.

(11) Die Mutter hat das Brot gekauft.

The mother has the bread bought

The mother has bought the bread.

When German-speaking children produce finite verb forms, they tend to mark them correctly for person, number and tense, while respecting the verb-second rule. However, when producing OI's, they tend to place the non-finite form in utterance-final position. This pattern is in line with the view that children in the OI stage distinguish between finite and non-finite forms in their input. It is taken by proponents of the OI hypothesis as evidence that children have already set all the inflectional and phrase structure parameters of their language.

In addition to providing a unified account of the cross-linguistic data, a key strength of the OI hypothesis is that it can also explain the pattern of verb-marking in children with DLD. Thus, Rice, Wexler & Cleave (1995) argue for an Extended Optional Infinitive (EOI) Stage in English-speaking children with DLD. Furthermore, Rice, Noll & Grimm (1997) provide an EOI analysis of the verb-marking deficit in a group of German-speaking children with DLD. They analysed spontaneous language samples from 8 children with DLD and 8 typically developing language-matched controls at two measurement points spaced roughly 12 months apart. The DLD group had an age range of 3;9 to 4;8 and a range of MLU in words of 2.00 to 3.66 at Time 1; the typically developing group had an age range of 2;1 to 2;7 and a range of MLU in words of 2.13 to 3.77. Rice et al. (1997) found that the DLD group produced significantly more OI's than the control group at Time 1 (though not at Time 2), and that both groups made very few agreement or verb-positioning errors, producing finite verbs in second position and non-finite verbs in utterance-final position. They therefore conclude that their results are consistent with an EOI account of the verb-marking deficit in DLD.

However, there are two potential problems with this conclusion. The first problem is that, in contrast to the MLU-matching effect Rice et al. (1995) found in English-speaking children with DLD, the MLU-matching effect found for German-speaking children (Rice et al., 1997) appears to be relatively short-lived, with both the DLD group and the MLU-matched controls producing very few OI's at the later MLU point. These data suggest that German-speaking children may only produce large numbers of OI's at low MLUs, and hence that there may be a difference in the rate at which English- and German-speaking children with DLD produce OI's at high MLUs that the EOI hypothesis cannot explain.

The second is that, although Rice et al. (1997) report very few agreement and verb-positioning errors in their study, other studies of German-speaking children with DLD have reported different results. For example, Clahsen, Bartke and Göllner (1997) report both agreement and positioning errors in their data, and argue that children with DLD may have a particular problem with agreement marking. In a more recent study, Rothweiler, Chilla and Clahsen (2012) compare German-speaking children with DLD and Turkish-German bilingual children. Rothweiler et al. (2012) report similar abilities in the two groups in their use of tense marking and complex syntactic structures such as wh-questions and embedded clauses. However, they also report that both groups struggled with the production of correctly agreeing verb forms. These findings count directly against Rice et al.'s (1997) conclusions. Rothweiler et al. (2012) note that one possible reason for this discrepancy is that Rice et al. (1997) restricted their agreement analysis to just two affixes, *-t* and *-st* and thereby "reduced the chances of finding agreement errors" (Rothweiler et al. 2012: 52).

The EOI hypothesis can be contrasted with accounts of verb-marking in children that attribute a much larger role to the child's input. These accounts take as their starting point the observation that, rather than occurring in free variation, finite verb forms and infinitives tend to occur in complementary distribution, with so-called OI's occurring in modal contexts, in which eventive verbs like 'play' or 'buy' are used to express desired or intended actions, while finite forms occur in non-modal contexts in which stative verbs such as 'want' or resultative verbs such as 'fall' are used to refer to states or changes of state. This pattern has been reported in a number of 'OI languages', including Dutch (Jordens, 1990; Wijnen, 1998); French (Ferdinand, 1996); German (Ingram & Thompson, 1996) and Swedish (Josefsson, 2002), and has led many researchers to question the claim that young children have adult-like knowledge of inflection. For example, Jordens (2012) argues for an initial lexical stage of development in which children do not have productive knowledge of verb movement or finiteness marking, while the form and position of the verb in the child's speech reflects the form and position in which it occurs in the input. This initial stage is followed by a functional stage in which children show the systematic use of topicalization and start to reorganize their grammar in a way that allows them to encode contextual information in their utterances. Evidence for the functional stage is the use of auxiliaries in second position. With the use of a functional verb in second position the child has discovered, that this position is used for verbal elements to express the pragmatic function of assertion. Jordens argues that "the contingency in the input between the position of the verb and its morphology makes it possible for the learner to discover the regularities of the variation in verbal morphology and thus to acquire the morphological properties of finiteness" (Jordens, 2012: 266).

Other input-driven models have sought to explain how the cross-linguistic pattern of verb-marking errors can be explained in terms of the interaction between the distributional properties of the language that the child is learning and the way the child processes this input. For example, in a series of studies, Freudenthal and his colleagues have shown that it is possible to simulate quantitative differences in the rate of utterances with OI's across a number of different languages as an outcome of the interaction between an utterance-final (and later edge-based[2]) bias in learning and the distributional properties of the input language (Freudenthal, Pine & Gobet, 2006, 2010, Freudenthal, Pine, Aguado-Orea & Gobet, 2007; Freudenthal, Pine, Jones & Gobet, 2015a; 2015b). Freudenthal and colleagues' Model of Syntax

[2] Based on the beginning (left edge) or the end (right edge) of an utterance

Acquisition in Children (MOSAIC) learns OI's from modal and other complex constructions in the input. Its utterance-final bias results in high rates of OI's in languages like Dutch and German, in which infinitives are tied to utterance-final position, and very low rates of OI's in Spanish in which utterance-final infinitives are much less common. The model is also able to simulate the tendency for OI's in German and Dutch to have modal semantics and to be restricted to eventive verbs (Freudenthal, Pine & Gobet, 2009). However, as Freudenthal et al. (2010) point out, it substantially underestimates the rate of OI's in English. Freudenthal et al. (2010) therefore argue for a Dual-Factor Model of verb-marking error in which some errors reflect the learning of OI's from modal structures and others reflect the tendency of the child to default to the most frequent form of the verb – which in English is the bare stem, and therefore results in defaulting errors that are indistinguishable from OI's.

The Dual-Factor Model can explain both the very high rate of OI's in English and the tendency of children learning more highly inflected languages to use the most frequent form of the verb in inappropriate contexts. For example, Freudenthal et al. (2015a) show that a version of MOSAIC that combines the model's utterance-final bias in learning with a frequency-based defaulting mechanism can not only simulate the very high rate of OI's in English, but also the tendency of Spanish-speaking children to produce third person singular (3sg) forms in non-3sg contexts (Aguado-Orea & Pine, 2015; Radford & Ploenning-Pacheco, 1995). However, the model also predicts that, in German, children will default to the infinitive at low MLUs and to the third person singular present tense form at higher MLUs – and will hence produce at least some verb-positioning and agreement errors when they substitute the default form into inappropriate contexts.

MOSAIC and the Dual-Factor Model have so far only been used to simulate data on typically developing children, but the ideas implemented in MOSAIC have been incorporated into Leonard and his colleagues' Competing Sources of Input account of the pattern of verb-marking deficit in children with DLD (Leonard, 2014; Fey, Leonard, Bredin-Oja & Deevy, 2017). According to this view, OI's in children with DLD reflect the inappropriate extraction of non-finite structures from more complex structures in the input, when they compete with finite constructions. This is due to a weakness in their ability to process the finite verb forms earlier in the sentence (e.g. *Does the girl run fast? He helped Mom do the dishes)*. Leonard and his colleagues provide support for this view using a variety of different experimental paradigms (e.g., Leonard & Deevy, 2011; Leonard, Fey, Deevy & Bredin-Oja, 2015; Purdy, Leonard, Weber-Fox & Kaganovich, 2014). They also provide evidence that at least some OI's in English-speaking children with DLD reflect defaulting to the bare stem. Thus, Kueser, Leonard and Deevy (2018) replicate a study by Räsänen, Pine and Ambridge (2014), which shows that English-speaking children's tendency to produce bare forms in 3sg elicitation contexts is significantly correlated with the relative frequency with which particular verbs occur as bare rather than 3sg forms in English child-directed speech. The Kueser et al. (2018) study shows the same effect in a group of children with DLD and a group of language-matched controls, with the children with DLD also producing significantly more bare forms in 3sg contexts than the typically developing children. The implication is that the Dual-Factor Model can also account for the pattern of verb-marking error in English-speaking children with DLD — though it is less obvious whether it provides a plausible account of the pattern of verb-marking error in German-speaking children with DLD.

The Present Study

It is evident that the EOI hypothesis and the Dual-Factor Model make different predictions about the pattern of verb-marking error in German-speaking children with DLD. With respect to OI's, the EOI hypothesis predicts that German-speaking children with DLD will produce OI's at higher rates than both age-matched and language-matched controls. Moreover, if it is to provide a unified account of the cross-linguistic pattern of verb-marking error in DLD, it should also predict an MLU-matching effect in German at high MLUs. The Dual-Factor Model, on the other hand, predicts that OI's in German will only occur at low MLUs, and hence that children with DLD will show a deficit relative to age-matched, but not language-matched controls. With respect to verb-positioning and subject-verb agreement errors, the EOI hypothesis predicts the absence of these kinds of errors, whereas the Dual-Factor Model predicts some verb-positioning errors and subject-agreement errors – and in particular the use of 3sg finite forms in non-3sg contexts. Finally, since, according to the EOI hypothesis, the occurrence of OI's reflects a difference between the child and the adult's underlying grammar, the EOI hypothesis predicts that correct finite forms and OI's will occur in free variation. However, the Dual-Factor Model predicts that correct finite forms and OI's in German will occur in complementary distribution, with verbs that occur as correct finite forms in the child's speech tending to occur as finite forms in the input and verbs that occur as OI's tending to occur as infinitives. In the present study we use rich corpus data from a German-speaking child with DLD and a typically developing language-matched control to test these predictions.

5.2 Methods

Corpora

In this study we compare data from two German corpora: the Bastian corpus and the Leo corpus. The Bastian corpus was made available by the Leibniz-Centre for General Linguistics in Berlin (Bittner, 2010). This corpus was originally meant to provide data on a monolingual typically developing German-speaking child, and consists of diary data for 9 months from the point when Bastian spoke his first words, followed by weekly 60- to 90-minute recordings from 1;8 to 7;4. These recordings were made in Bastian’s home environment in everyday situations when he was interacting with his parents or his younger sister and are transcribed in CHAT format (MacWhinney, 2000). At the age of 4;6, Bastian was diagnosed with Developmental Language Disorder and began to receive therapy. His corpus thus provides detailed data on the early language development of a German-speaking child with DLD. The transcripts used in this study cover the age range from 3;0 to 4;6. They consist of 104 recordings and include 19,061 child utterances.

The Leo corpus was collected by the Max Planck Institute for Evolutionary Anthropology in Leipzig (Behrens, 2006). Leo’s speech was recorded and transcribed for three years from the age of 1;11 to 4;11. In Leo’s third year, five 60-minute recordings were made per week. Over the following years (until 4;11), five 60-minute recordings were made per month. These recordings were made in Leo’s home environment in everyday situations when he was interacting with his parents or the researcher, and are also transcribed in CHAT format. The whole corpus consists of 383 recordings and includes 158,336 child utterances. Since the corpus is so extensive, Behrens (2006) is able to provide a very detailed description of Leo's language development. However, in the present study, we only analyse data from the period when Leo's age ranged from 2;2 to 2;7.

Procedure

In order to compare Bastian's data with data from Leo matched for MLU, the MLU for Leo and Bastian was calculated for each transcript. In line with Rice et al.'s (1997) analysis, MLU in words was used to control for differences in the morphological complexity of the children's speech. Bastian's transcripts were then merged into monthly datasets, and transcripts were selected from Leo's corpus to provide a corresponding dataset with the same MLU in words based on a similar number of utterances (see Figure 3 for an example of this procedure).

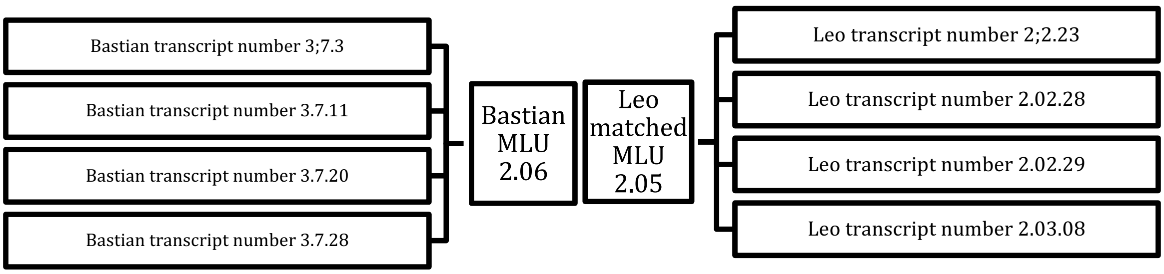

Figure 3: Example of MLU-matching procedure for one monthly dataset for Bastian and Leo

This procedure resulted in 8 matched datasets covering the period from 3;4 to 4;0 for Bastian. One of these datasets collapsed across the ages 3;10 and 3;11, because, for these months there were fewer data points. For Leo the matched datasets cover an age range from 2;2 to 2;7. These data are used for analyses 1 and 2.

Once matching was complete, we followed the same exclusion criteria as Rice et al. (1997). First, we excluded all of the following utterance types: false starts and immediate imitations and self-repetitions; recitations of songs or stories; motor or play noises (e.g., *brumm brumm*); and utterances containing the child's idiosyncratic words or phrases. Second, we excluded all imperatives and questions. Third, we excluded all utterances that did not include an overt subject. Finally, we excluded all utterances that consisted of less than 3 constituents. Note that the use of this final criterion (in which we also follow Rice et al. (1997)) is designed to focus the analysis of OI rates on declarative utterances in which the verb can be unambiguously classified as a finite or non-finite form and in which verb-positioning and agreement errors can therefore be clearly identified. However, it is worth noting that it does result in a large number of utterances being excluded from the analysis. For example, Bastian’s 3;7 dataset consisted of 1039 utterances, 293 of which included a verb, but only 61 of which included an overt subject and at least 3 constituents.

These criteria were implemented by using the kwal program in CLAN to extract all fully intelligible utterances with three or more words that included a finite lexical verb, an infinitive or a modal from each child’s data on the basis of the %mor tier in the transcripts. This tier contains an utterance-by-utterance morpho-syntactic coding of the child’s (and the adult’s) speech. The resulting output files were then checked by hand against the criteria and used to perform the following analyses for each of the two children. The kwal program was also used to extract all of the adult utterances that included finite and infinitive forms of the verbs used by the children. These output files were also checked by hand and any instances where infinitives had been incorrectly coded as plural verb forms were corrected.

Coding and Analysis

Rate of OI's

The rate of OI's at each data point was established by identifying the number of utterances with 3 or more constituents including an overt subject and calculating the percentage of these utterances that were OI's as opposed to correct finite forms. In line with Rice et al. (1997), periphrastic structures such as modal + infinitive constructions were not included in this analysis. The percentages of OI's at each MLU point were then compared using Chi square or Fisher's Exact tests.

Rates of Verb-positioning Errors

Rates of verb-positioning errors were established by distinguishing between infinitives that occurred in utterance-final position and infinitives that occurred in second position and calculating the percentage of the utterances in which the infinitive occurred in second position; and by distinguishing between finite verbs that occurred in second position and finite verbs that occurred in utterance-final position and calculating the percentage of these utterances in which the verb occurred in utterance-final position. Rates are reported for the data before and after the children reached an MLU of 2. However, since there were fewer utterances with 3 or more constituents before than after the children reached this point, utterances from Bastian's earlier transcripts (Age 3;0 to 3;3, MLU=1.63) were added to the analysis, together with matched data from Leo, in order to increase the sample size.

Rates of Subject-Verb Agreement Errors

Rates of subject-verb agreement errors were established by identifying all finite verbs that occurred with 3 or more constituents including an overt 1sg, 2sg, 3sg or 3pl subject and calculating the rate at which the child used a verb with incorrect person or number marking in a 1sg, 2sg, 3sg or 3pl context. Separate error rates are reported for each of these contexts.

Rate of OI's per verb in the child's speech and rate of infinitives per verb in the input

Rates of OI's in the child's speech were also calculated on a verb-by-verb basis, together with the rates of infinitives per verb in the input. The rates of OI's per verb in the child's speech are based on all of the utterances with 3 or more constituents including an overt subject that Bastian produced between 3;0 and 4;6 and on the matching data from Leo. The rates of infinitives in the input are based on all the maternal utterances containing verbs in each of Bastian's and Leo's corpora. The child data were then used to compare the rate at which OI's occurred with stative (state or change of state), eventive (or agentive) and ambiguous verbs, applying Jordens' (2012) classification, and the child and adult data were used to assess the relation between the relative frequency with which verbs occurred in infinitive versus finite form in the input and the rate at which they occurred as OI's in the child's speech.

Reliability

The reliability of the coding of subject-verb agreement errors and verb-positioning errors was assessed by having a second independent coder (who is a native speaker of German) code 48.32% of Bastian's and Leo's utterances. The Cohen's Kappa coefficient for subject-verb agreement was 0.89 and the Cohen's Kappa coefficient for verb-positioning errors was 0.91, indicating a high level of agreement.

5.3 Results

The aim of the present study was to use data from two rich corpora of early child German, one from a child with DLD: Bastian, and one from a typically developing child: Leo, to test the predictions of two different accounts of the pattern of verb-marking deficit in DLD: the EOI hypothesis and the Dual-Factor Model. In the first analysis, we focus on the question of whether there is a stage in Bastian's development in which he produces OI's at higher rates than Leo at equivalent MLUs. The second and third analyses focus on the question of whether Bastian and Leo make verb-positioning and subject-verb agreement errors in their speech – and whether such errors are more common in Bastian's speech. In a final analysis, we focus on the question of whether Bastian's and Leo's tendency to produce OI's with particular verbs is predicted by the relative frequency with which those verbs occur as infinitive versus finite forms in their input.

Does Bastian produce OI's at higher rates than would be predicted on the basis of his MLU?

A key prediction of the EOI hypothesis is that there will be a stage in the development of German-speaking children with DLD in which they produce OI's at higher rates than typically developing children at equivalent MLUs. In contrast, the Dual-Factor Model predicts that, since OI's reflect a process of building syntactic knowledge from the right edge of the utterance, the rate of OI's in both groups will be primarily determined by the length of the utterances that the child is able to produce. There will therefore be no difference in the rate of OI's at equivalent MLUs. These predictions were tested by computing the rate of OI's versus correct finite forms in utterances with 3 or more constituents in MLU-matched samples of Bastian's and Leo's speech. Table 5 shows examples of Bastian and Leo's use of correct finite forms and OI's. In line with Rice et al. (1997), compounds such as modal + infinitive constructions were not included in the analysis[3].

Table 5: Examples of correct finite forms and OI's in Bastian's and Leo's speech

Bastian	
Correct finite forms	*OI's*
Igel macht alle (3;1) Hedgehog empties all *Hexe schläft da* (3;4) Witch sleeps there *Sonne scheint Möwe* (3;6) Sun shines seagull	*Mama auch machen* (3;0) Mama also do-INF *Bastian Haus mal(e)n* (3;4) Bastian house draw-INF *Omi auch kleben* (3;6) Grandma also stick-INF
Leo	
Correct finite forms	*OI's*
Eichi fliegt mit (2;2) Eichi flies with *Da hält der Zug* (2;4) There stops the train *Der Sägefisch kriegt auch ein Pflaster* (2;5) The sawfish gets also a plaster	*Oma Brücke bauen* (2;2) Grandma bridge build-INF *Papa mit Eisenbahn spielen* (2;3) Daddy with train play-INF *Du auch was finden* (2;5) You also what find-INF

[3] Note that since periphrastic structures were not included in this analysis, Leo's lower rates of OI's reflect the production of a higher proportion of finite lexical verbs. A breakdown of Bastian's and Leo's use of OIs, finite lexical verbs and periphrastic structures is provided in Appendix D. This shows that Leo and Bastian produced periphrastic structures at roughly similar rates over the period in question and confirms that the main difference between the two children was the rate at which they produced OI's and finite lexical verbs.

The results of this analysis are plotted in Figure 4 from which it can be seen that there is a stage between 3;6 and 3;11 during which Bastian produces OI's substantially more frequently than Leo at equivalent MLUw's. The differences in rates at all of the points between 3;6 and 3;11 were analysed using Chi-square or Fisher's Exact tests. With the exception of the difference at 3;6, (X^2 = 3.30, p = .069), all of these differences were statistically significant (all X^2s > 8.00, all ps < .005).

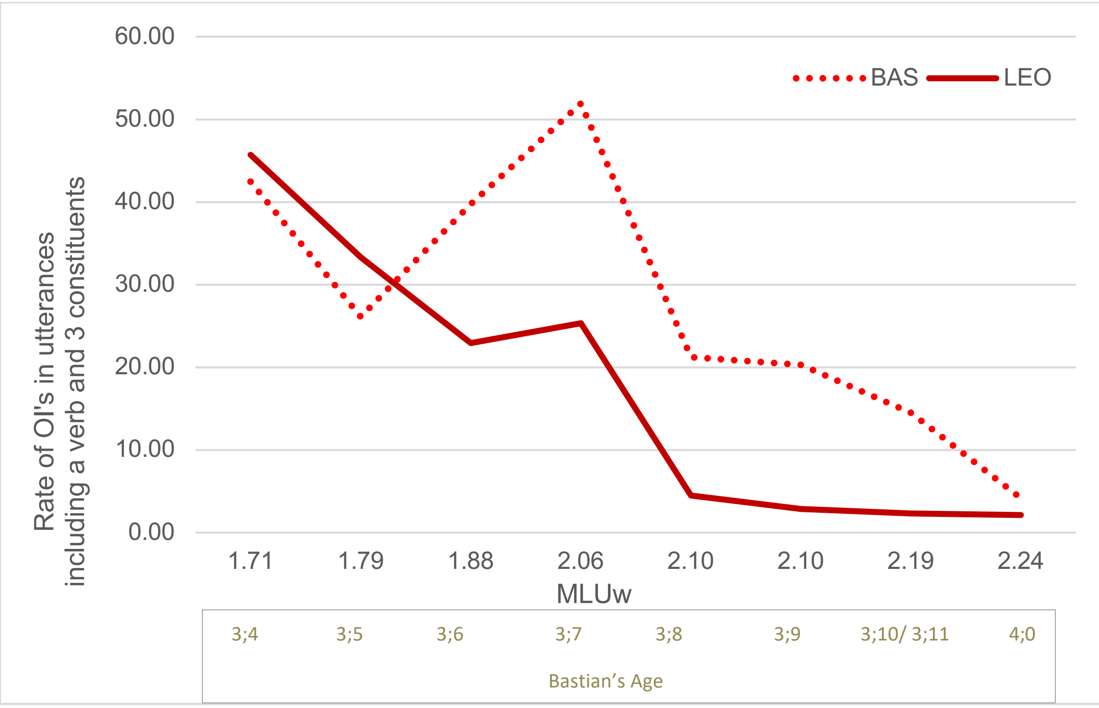

Figure 4: Rates of OI's produced by Bastian and Leo at equivalent MLUw's

However, it is also clear from Figure 4 that the stage during which the relevant effect can be seen is restricted to a very narrow MLU range (from 1.88 to 2.19), with Bastian's rate of OI's decreasing to less than 5% at the next MLU point (2.24), which is not significantly different from Leo's (p = .6025 by Fisher's Exact).

These results provide some support for Rice et al.'s (1997) claim that there is a stage during which German-speaking children with DLD produce OI's at higher rates than MLU-matched controls. However, they also suggest that this stage is much shorter than that reported for English-speaking children – who show MLU-matching effects at much higher MLUs – and hence that it is much shorter than would be predicted by the EOI hypothesis.

An alternative possible interpretation of the data, that is broadly consistent with the Dual-Factor Model, is that the MLUw values reported in Figure 4 hide differences between the two children in the average length of their utterances including verbs (MLUv) – and that it is these differences rather than differences in MLUw that predict the differences in the children's rates of OI's. This possibility was investigated by computing the average length of utterances including verbs (MLUv) across the MLU range and comparing these values across the two children. The results of this analysis are reported in Figure 5 and show that, although the average length of utterances including verbs increases for both children (by around 2 words for Leo and 1 word for Bastian over the period in question), it is always higher in Leo than Bastian at equivalent MLUw's. This difference is statistically significant using a paired sample t-test ($t = 4.71$, $p = .002$).

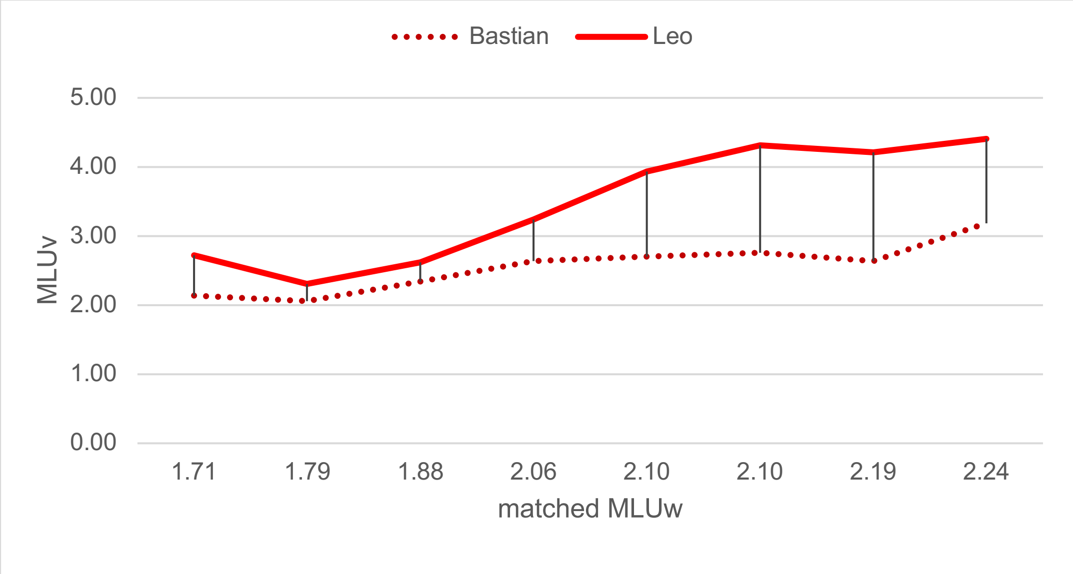

Figure 5: Comparison of MLUv's for Bastian and Leo, when matched on MLUw

In view of this difference, we conducted an additional analysis in which we compared Bastian and Leo's rates of OI's at the three points at which they had similar MLUv's[4]. The results of this analysis are plotted in Figure 6 and show that the two children produce OI's at similar rates at the first two data points (Both X^2s < .60, both ps > .479), but that at the third data point Bastian's rate of OI's is actually significantly lower than Leo's ($X^2 = 7.74$, $p = .005$). In short, there is no evidence that Bastian produces OI's at higher rates than Leo when we control for the average length of his utterances including verbs.

[4] Note that for Bastian there are two data points at which his MLUv was 2.64. Bastian's rate of OI's at MLUv = 2.64 was therefore calculated by collapsing across these two data points

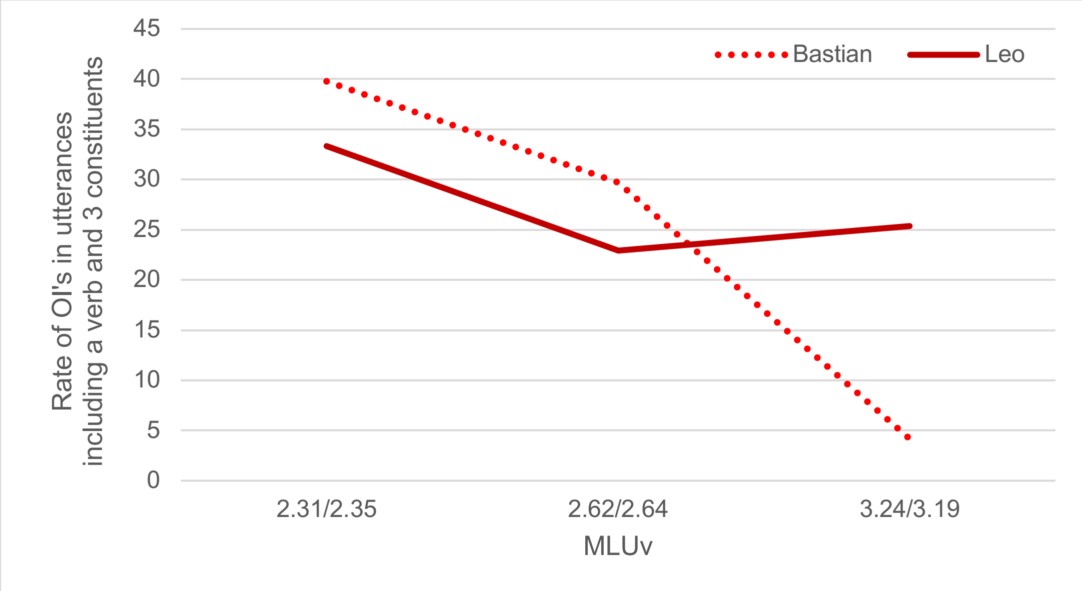

Figure 6: Rates of OI's produced by Bastian and Leo at equivalent MLUv's

When taken together with the results presented in Figure 4, these results suggest that there is little real evidence for a stage in which Bastian produces more OI's than would be predicted on the basis of the length of the utterances that he produces – or at least on the basis of the length of his utterances including verbs. The data are therefore broadly consistent with the prediction of the Dual-Factor Model that the rate at which German-speaking children with DLD produce OI's is primarily determined by the length of the utterances that they are able to produce.

Does Bastian make verb-positioning errors – and are these errors more common in Bastian's than in Leo's data?

The EOI hypothesis predicts that, although German-speaking children with DLD will produce OI's at high rates, they will rarely produce positioning errors in which they use infinitives in second position (e.g. **Oma gucken Haus* – **Grandma look-INF house)* or finite verbs in utterance-final position (e.g.

**hier Onkel passt – *Here uncle fits-3sg present)*. The Dual-Factor Model, on the other hand, predicts positioning errors when children with DLD (and to a lesser extent typically developing children) default to the most frequent form of the verb in their input.

These predictions were tested on Leo's and Bastian's data by looking at transcripts before and after the children reached an MLU of 2 (Figure 7). Both children made positioning errors, particularly before MLU 2, when they both produced infinitives in second position at relatively high rates (32.4% for Bastian and 23.3% for Leo). However, Bastian made significantly more errors than Leo both before MLU 2 ($X^2(1, N=396) = 11.03, p = .001$) and after MLU 2 ($X^2(1, N=887) = 49.02, p < .001$), with Leo's rate of positioning errors decreasing to close to zero at the later measurement point.

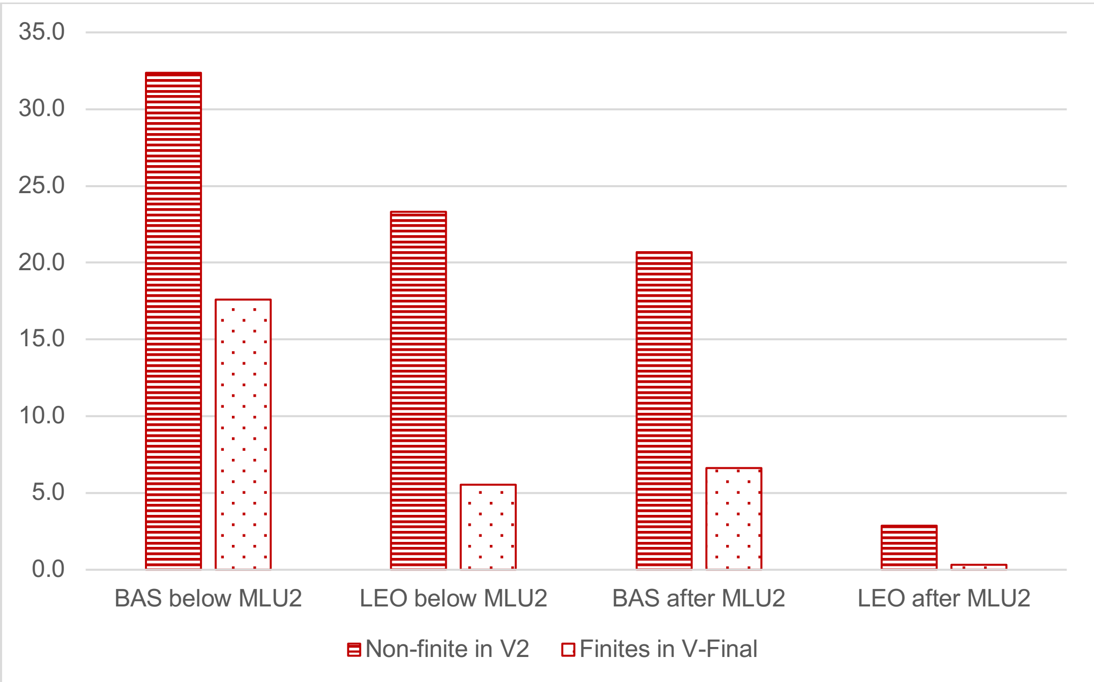

Figure 7: Rates of positioning errors in Bastian and Leo

These results count directly against the predictions of the EOI account that German-speaking children with DLD will not make positioning errors, and in favour of the predictions of the Dual-Factor Model. Moreover, given that the most common type of error in Bastian's speech appears to be positioning errors that reflect the use of infinitives in second position, they are also consistent with the view that these errors reflect a process of defaulting to the form of the verb that occurs most frequently in utterance-final position in the input (see Table 6 for examples).

Table 6: Examples of Bastian's and Leo's verb-positioning errors

Bastian		**Leo**	
Finite forms in final position	*Infinitives in finite position*	*Finite forms in final position*	*Infinitives in finite position*
Da Puzzle fehlt (3;8) There puzzle is missing *Maus nicht schläft* (3;9) Mouse not sleeps *Hubschrauber das hier kommt* (3;11) Helicopter this here comes *Das Mädchen dreckig Teller leckt* (4;0) The girl dirty plate licks	*Auto gehen nicht* (3;7) Car work-INF not *Tierpark bauen ich wieder gleich* (3;11) Zoo build-INF I again soon *Mama spielen heute mal Karten* (4;2) Mummy play-INF today some cards	*S-Bahn nach Möckern fährt* (2;2) S-Bahn to Möckern drives *Erni was so alles macht* (2;2) Erni what so all does *Noch die malt* (2;1) Also this paints *Ein Zug nur Sommer fährt* (2;4) A train only summer drives	*Große Eistüte bauen hier* (2;2) Big ice-cream cone build-INF here *Elefant alle Mäuse malen Himmel* (2;2) Elephant all mice paint-INF heaven *Auto fahren Schaf* (2;2) Car drive-INF sheep

Does Bastian make subject-verb agreement errors – and are these errors more common in Bastian's than in Leo's data?

A further prediction of the EOI hypothesis is that children with DLD and typically developing children will rarely produce subject-verb agreement errors in which a finite form of the verb is used in the wrong person/number context. The Dual-Factor Model, on the other hand, predicts that children with DLD (and to a lesser extent typically developing children) will sometimes default to the most frequent form of the verb in the input and hence produce subject-verb agreement errors. Table 7 shows the rate of subject-verb agreement errors in Bastian's and Leo's speech. This analysis was done on all finite verbs that occurred with an overt 1sg, 2sg, 3sg or 3pl subject and 3 or more constituents in Bastian's transcripts from 3;0 to 4;6 and Leo's matching transcripts.

Table 7: Rate of subject-verb agreement errors in Bastian's and Leo's speech

Form		**all forms**	**correct forms**	**incorrect forms**	**error in %**	**error type**
1st Singular	Bastian	171	135	36	21.1	3rd Person Singular (N=36)
	Leo	10	10	0	0	
2nd Singular	Bastian	33	33	0	0	
	Leo	8	8	0	0	
3rd Singular	Bastian	310	310	0	0	
	Leo	207	207	0	0	
3rd Plural	Bastian	18	17	1	5.7	3rd Person Singular
	Leo	34	31	3	8.8	3rd Person Singular (N=3)

It is clear from Table 7 that subject-verb agreement errors are extremely rare in Leo's data (only three instances of 3sg forms in 3pl contexts). However, it can also be seen that Bastian makes a relatively large number of errors (37 in total), particularly in 1sg contexts, where the error rate is over 20%. Interestingly, all of Bastian’s errors reflect the incorrect use of the 3sg (suffix –t) form (e.g. **Ich hat das Fenster – *I has the window; *Ich holt zwei Zettel – *I gets two notes)*. These errors count directly against the predictions of the EOI hypothesis and are consistent with the view that German-speaking children with DLD make subject-verb agreement errors that reflect a process of defaulting to the highest frequency form of the verb in the input.

Do Bastian and Leo tend to produce OI’s with particular verbs in a way that reflects the relative frequency with which those verbs occur as infinitive versus finite forms in their input?

According to the EOI hypothesis, the pattern of verb marking error in the language of German-speaking children with DLD reflects a maturationally-determined difference in the child and the adult’s underlying grammar. Therefore, the EOI hypothesis predicts no relation between children’s tendency to produce OI’s with particular verbs and the rate at which those verbs occur in particular forms in the input. However, input-driven models like the Dual-Factor Model predict that both typically developing children and children with DLD will be more likely to produce OI’s with eventive than stative verbs (including changes of state) and that the rate at which OI’s occur with particular verbs will reflect the relative frequency with which those verbs are used in infinitive versus finite form in the input.

These predictions were tested, first, by classifying all the verbs produced by Bastian and Leo as stative, eventive or ambiguous, in line with Jordens’ (2012) classification, and comparing the rate at which these verbs occurred as OI's as opposed to correct finite forms in each of the children's speech; and, second by correlating the rate at which children produced particular verbs as OI's and the rate at which those verbs occurred as infinitives versus finite forms in the child's input.

Table 8 presents the mean rates of OI's in Bastian and Leo for eventive, ambiguous and stative verbs. Analysis of these data using one way analysis of variance revealed a significant effect of verb type in both children ($F(2,29) = 30.14$, $p < .001$ for Bastian and $F(2,42) = 10.69$, $p < .001$ for Leo). In both cases, the rate of OI's was significantly higher for eventive than stative verbs and significantly higher for eventive than ambiguous verbs ($p < .001$ and $p = .003$, respectively for Bastian and $p < .001$, and $p = .042$, respectively for Leo). These results count against the EOI hypothesis and are consistent with the prediction of input-driven models that children tend to produce OI's and correct finite utterances with semantically different sets of verbs.

Table 8: Mean rates (+ SDs) of OI's for eventive, ambiguous and stative verbs for Bastian and Leo

	%Eventive (SD)	%Ambiguous (SD)	%Stative (SD)
Bastian	80.0 (15.4)	41.5 (17.8)	19.1 (25.6)
Leo	76.5 (34.0)	38.6 (16.7)	27.6 (35.8)

Figures 8 and 9 present scatterplots of the relation between the rate at which the two children produced particular verbs as OI's and the rate at which those verbs occurred as infinitives versus finite forms in their input. In both cases there is a significant positive correlation between the two variables ($r(40) = .69$, $p < .001$ for Bastian and $r(86) = .49$, $p < .001$ for Leo).

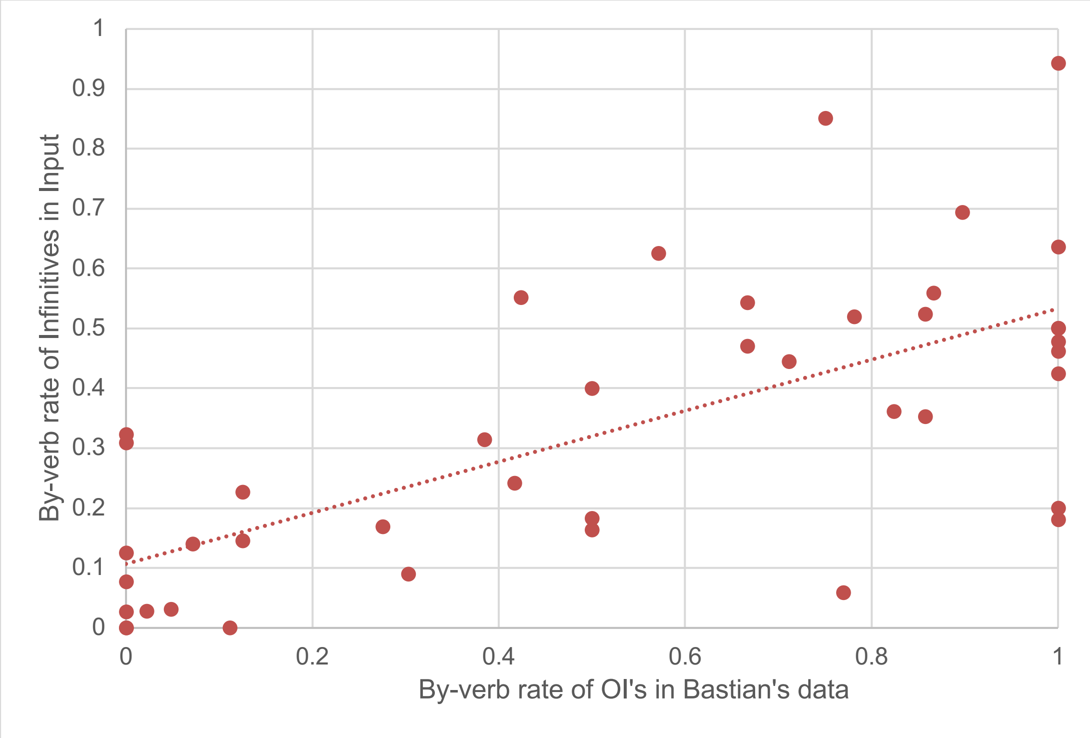

Figure 8: The relation between the by-verb rate of OI's in Bastian's data and the by-verb rate of infinitives in Bastian's input

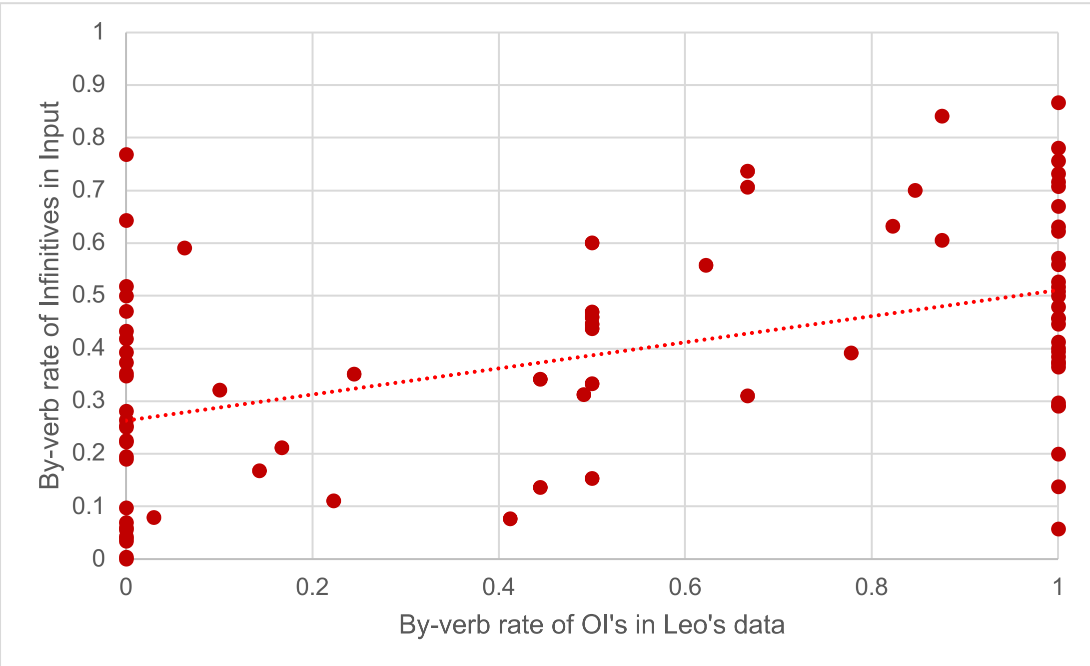

Figure 9: The relation between the by-verb rate of OI's in Leo's data and the by-verb rate of infinitives in Leo's input

These results provide further support for an input-driven account of the pattern of OI's in German-speaking children and suggest that the semantic-conditioning of OI's in these children's speech reflects the way that semantically different sets of verbs are used in the child's input. It may also be tempting to take the higher correlation in Bastian's data as evidence that Bastian is more strongly influenced by the input than his typically developing counterpart. However, caution should be exercised here since the difference between the two correlations is not significant ($p > .10$).

5.4 Discussion

The aim of this study was to use rich corpus data from a German-speaking child with Developmental Language Disorder (Bastian) and a typically developing language-matched control child (Leo) to compare two different models of the verb-marking deficit in DLD: the EOI hypothesis and the Dual-Factor Model.

In a first analysis, we focused on the question of whether there was a stage in Bastian's development during which he produced OI's at higher rates than Leo at equivalent MLUs. In line with the EOI hypothesis, our analysis did reveal such a stage. However, this stage was relatively short-lived, with the rate of OI's in both children's speech dropping to less than 5% before they reached an MLU of 2.5. These results provide some support for the EOI hypothesis, but they also raise doubts about its potential to explain the pattern of error across languages, since English-speaking children with DLD appear to show MLU-matching effects much further up the MLU range. For example, Rice et al. (1995) report significant differences in rates of OI's between

English-speaking children with DLD and MLU-matched controls at MLUs ranging from 2.78 to 4.44. Our results are broadly consistent with the Dual-Factor Model, which predicts that the rate at which German-speaking children produce OI's will be primarily determined by the length of the utterances that they are able to produce. Interestingly, further exploratory analysis revealed that even in speech samples matched for MLU in words, there was a tendency for Bastian's utterances with verbs to be shorter on average than those of Leo, suggesting that matching for MLU in words may not fully control for differences in the complexity of the speech of children with DLD and typically developing children.

In a second analysis, we focused on the question of whether Bastian and Leo made verb-positioning errors in their speech – and whether such errors were more common in Bastian's than in Leo's data. Contrary to the predictions of the EOI hypothesis, both Bastian and Leo did make verb-positioning errors in their speech, including the use of infinitives in verb second position and the use of finite forms in utterance-final position. There are some alternative explanations in the literature for the production of finite forms in utterance-final position. For example, they could reflect the fact that the child is at a preliminary stage in the acquisition of subordination and is trying to produce a subordinated clause with the conjunction *weil* (because) omitted (Rothweiler, 1993; Müller & Penner, 2009). Alternatively, the children could be trying to produce a participle construction, but omitting the auxiliary and reducing the prefix *ge-* (Marcus, Brinkmann, Clahsen, Wiese & Pinker; 1995), which would result in a form that looks like a finite verb. However, infinitives in verb second position were more common than finite forms in utterance-final position, and Bastian made significantly more errors than Leo, who made virtually no verb-positioning errors after MLU 2. These results count directly against the predictions of the EOI hypothesis, and are in line with the predictions of the Dual-Factor Model. Moreover, given that the most common type of error in Bastian's speech is the use of infinitives in second position, they are also consistent with the view that these errors reflect a process of defaulting to the form of the verb that occurs most frequently in utterance-final position in the input. Another possible explanation of the relatively high rate of infinitives in verb second position is Jordens' suggestion that such errors may reflect the addition of a constituent to a correctly-formed utterance as an afterthought aimed at providing additional information. For example, an utterance such as *Mama spielen Ball – Mummy play-INF ball*, could be interpreted as *Mama spielen. Ball – Mummy play-INF Ball* with the infinitive *spielen* in utterance-final position and the object *Ball* added to the utterance as an afterthought to provide additional information about what the child wants the mother to play with. Some of the positioning errors in our analysis might be explained in this way. For example, the *hier* in Leo's utterance: *Große Eistüte bauen hier – big ice cream cone build-INF here* might plausibly be interpreted as an afterthought aimed at providing additional information about where the child wants to build the cone. However, there are also instances of infinitives in verb-second position that cannot be explained in this way, such as Bastian's utterances: *Tierpark bauen ich wieder gleich – Zoo build-INF I again soon* and *Auto gehen nicht – Car work-INF not*. These utterances are consistent with the idea that Bastian substitutes infinitives into verb-second position when the correct finite form is only weakly represented in his system, as the Dual-Factor Model would predict. In future work, prosodic analysis could be used to investigate whether such utterances are ellipses on the part of the child – which could explain their apparently non-target-like word order.

In a third analysis, we focused on the question of whether Bastian and Leo made subject-verb agreement errors in their speech. Although such errors were extremely rare in Leo's data, they were relatively common in Bastian's data, particularly in first person singular contexts. Interestingly, all of these errors involved the incorrect use of the 3sg present tense form in a non-3sg context. This pattern is consistent with the claim that, contrary to the predictions of the EOI hypothesis, German-speaking children with DLD do have problems with subject-verb agreement (Clahsen & Rothweiler, 1993; Rothweiler et al., 2012). It is also consistent with the assumption of the Dual-Factor Model that these problems reflect a tendency to default to the highest frequency form of the verb in the input, when the correct form of the verb is only weakly represented in the child's system (Freudenthal et al., 2015a and in prep.).

In a final analysis, we focused on the question of whether Bastian and Leo tended to produce OI's and correct finite forms with semantically-different sets of verbs, and whether this tendency could be explained in terms of the relative frequency with which those verbs occurred as infinitive versus finite forms in their input. In both children, the rate of OI's was significantly higher for eventive than stative and ambiguous verbs. This finding counts against the prediction of the EOI Hypothesis that OI's and correct finite forms will occur in free variation in the child's speech, and is consistent with the claim that finite and non-finite verb forms tend to occur in complementary distribution, with OI's occurring in modal contexts, in which eventive verbs like ‘play’ or ‘buy’ are used to express desired or intended actions, and finite forms occurring in non-modal contexts in which stative verbs such as ‘sit’ or resultative verbs such as ‘fall’ are used to make assertions about states or changes of state (e.g. Jordens, 1990; Ingram & Thompson, 1996). In both children, there was also a significant correlation between the rate at which they produced OI’s with particular verbs and the relative frequency with which those verbs occurred as infinitive versus finite forms in their input. This finding suggests that the semantic conditioning of OI’s in the children’s speech reflects the way that semantically different sets of verbs pattern in the child’s input.

When taken as a whole, the results of these analyses provide little support for the EOI hypothesis, and are broadly consistent with the Dual-Factor Model and other input-driven accounts of the pattern of verb-marking error in children with DLD (e.g. Jordens, 2012; Leonard et al., 2015). Of course, one obvious limitation of the study is that it is based on only one child with DLD and one language-matched control, and therefore needs to be replicated on a larger number of children. On the other hand, it is also important to recognize that, because it is based on two very rich longitudinal corpora, the amount of data that each child provides is much larger than that analysed in most previous studies. Moreover, it is also worth noting that, although inconsistent with the EOI hypothesis, the results of the present study are actually quite consistent with the results of previous research in the area in the following respects.

First, the finding that the MLU-matching effect in German DLD is relatively short-lived actually mirrors the pattern of results in Rice et al.’s own study, where an MLU-matching effect was only observed at the first measurement point (Rice et al., 1997). In this study the rate of OI's had dropped to less than 10% a year later. The implication is that German-speaking children may only produce large numbers of OI's at low MLUs. Hence, there may be a difference in the rate at which English- and German-speaking children make OI's later in development that the EOI hypothesis cannot explain.

Second, the finding that German-speaking children with DLD do make verb-positioning and agreement errors is consistent with the results of a number of studies of DLD in German which suggest that these children have problems with word order and agreement. For example, Leonard (2014) reviews a number of studies of DLD in German and concludes that "word order errors abound in these children" (Leonard, 2014: 100). Furthermore, Rothweiler et al. (2012) compare a group of German-speaking children with DLD and a group of Turkish-German bilingual children and report that both groups struggled with the production of correctly agreeing verb forms. They also note that one possible reason for the discrepancy between their findings and those of Rice et al. (1997) is that Rice and colleagues only included finite forms with the two affixes, *-t* and *-st* in their agreement analysis.

Finally, the finding that there are semantic-conditioning effects on the rate at which both Bastian and Leo make OI's is consistent with a wealth of cross-linguistic evidence that OI's and finite forms do not occur in free variation in children's speech (Ferdinand, 1996: Ingram & Thompson, 1996; Jordens, 1990; 2012; Josefsson, 2002; Wijnen, 1998). As we have shown, these effects can be explained in terms of the rate at which particular verbs occur as infinitives versus finite forms in the input. This is consistent with two recent studies that document significant input effects in Dutch, English, French, German and Spanish children (Freudenthal, et al., 2010) and French and German children (Laaha & Bassano, 2013). To summarize, the results of the present study are broadly consistent with the results of previous research on OI's in German and other languages, and provide further support for input-driven accounts of these errors. They also support the idea that our understanding of the relation between the pattern of errors in children's speech and the distributional properties of the input could be used to shape therapy for German-speaking children with DLD. A good example of this kind of approach is Fey et al.'s (2017) intervention study, in which they tested a therapy for the verb-marking deficit in English-speaking children with DLD based on Leonard's Competing Sources of Input account (Leonard, 2019).

5.5 Conclusion

In the present study, we have used rich corpus data from a German-speaking child with DLD and a typically developing language-matched control to compare two different accounts of the verb-marking deficit in children with DLD. Our results provide little support for the EOI hypothesis, and are broadly consistent with the Dual-Factor Model and other input-driven accounts of the pattern of verb-marking error in children with DLD (e.g. Jordens, 2012; Leonard et al., 2015). Future research should seek to replicate these results on a larger sample of children.

CHAPTER 6: Testing two different models of the pattern of verb-marking error in German-speaking children with Developmental Language Disorder and language-matched controls

6.0 Rationale for the Study reported in Chapter 6

The results of the study reported in the previous chapter were broadly consistent with the Dual-Factor Model, but were based on data from a single German-speaking child with DLD and a single MLU-matched control. The study reported in the following chapter therefore seeks to build on these results by testing the predictions of the EOI Hypothesis and the Dual-Factor Model on a larger group of children. This study uses the same elicitation paradigm used to test English-speaking children in Chapter 4. It hence seeks to extend the results reported in Chapter 5 not only to a larger sample of children but also from a naturalistic to an experimental setting.

The EOI Hypothesis predicts that the DLD group will produce OI errors at significantly higher rates in both the modal and the non-modal conditions and that there will be no effect of context and no effect of input. The Dual-Factor Model predicts that that there will be no significant difference between the two groups, but that both groups will produce OI errors at significantly higher rates in the modal condition and that both groups will show an input effect in the non-modal condition.

The results provide support for the prediction of the Dual-Factor Model that both groups of children will produce more OI errors in modal than in non-modal contexts, but no support for the hypothesis that both groups will show an input effect in the non-modal condition. They also fail to provide any support for the prediction of the EOI hypothesis that there will be a significantly higher rate of OI errors in the DLD group. However, these results must be treated with caution since rates of avoidance were unacceptably high and correlated with the input-bias predictor (i.e., higher for verbs that appear predominantly in simple-finite form in the input). The study therefore needs to be replicated after appropriate modifications have been made to the design to eliminate this problem.

This article will be submitted to a peer-reviewed journal.

6.1 Introduction

Verb-marking errors are a characteristic feature of children's early language. However, there is evidence that children with Developmental Language Disorder (DLD) show a particular deficit in verb marking. For example, both English-speaking and German-speaking children have been reported to go through a stage in which they make significantly more verb-marking errors than typically developing language-matched controls (Rice, Noll & Grimm, 1997; Rice, Wexler & Cleave, 1995). Generativist models of this deficit view it as the result of a biologically based deficit in the child's underlying grammar. Constructivist models view it as the result of a processing deficit that affects the way in which the child analyses the input language. In this paper, we investigate these two possibilities by testing two specific models of the verb-marking deficit in DLD: the generativist Extended Optional Infinitive (EOI) hypothesis (Rice & Wexler, 1996; Rice et al., 1995) and the constructivist Dual-Factor Model (Freudenthal, Pine & Gobet, 2010; Freudenthal, Pine, Jones & Gobet, 2015a), on a group of German-speaking children with DLD and a group of typically developing German-speaking children matched in terms of their

Mean Length of Utterance (MLU). We use a verb elicitation paradigm to compare the children's performance in modal and non-modal contexts on a set of verbs that vary in the extent to which they occur as infinitives as opposed to finite forms in German child-directed speech. The EOI Hypothesis predicts that German-speaking children with DLD will show a deficit relative to MLU-matched controls in both modal and non-modal contexts and that there will be no correlation between either group's tendency to produce Optional Infinitive (OI) errors with particular verbs and the relative frequency with which these verbs occur as infinitive versus finite forms in German child-directed speech. The Dual-Factor Model predicts that German-speaking childen with DLD will not show a verb-marking deficit relative to MLU-matched controls in either modal of non-modal contexts, but that both groups will produce OI errors at higher rates in modal contexts, and that there will be a correlation between both groups' tendency to produce OI errors with particular verbs in non-modal contexts and the relative frequency with which these verbs occur as infinitive versus finite forms in German child-directed speech.

The Optional Infinitive Phenomenon

Verb-marking errors are a characteristic feature of children's early language. For example, between the ages of 2 and 4 years, English-speaking children often produce zero-marked verb forms in contexts that require a third person singular (3sg) present tense or a past tense form (see 1 to 4 for examples taken from the Manchester corpus (Theakston, Lieven, Pine, & Rowland, 2001) in the CHILDES database (MacWhinney, 2000).

1) *Anne like strawberries (Anne, 2;1.08)
2) *He want to go (Carl, 2:8.15)

3) *We make this yesterday (Gail, 2;8.13)

4) *And Caroline come yesterday (Nicole, 2;9.09)

Traditionally, these kinds of errors have been taken to reflect incomplete knowledge of the target inflectional system (e.g. Brown, 1973), or the dropping of inflections as a result of processing limitations in production (Bloom, 1990; Valian, 1991). However, analysis of early production data in languages other than English has revealed patterns of verb-marking error that cannot be readily explained in these terms. For example, studies of early child French, German and Swedish have all reported errors involving the use of infinitive forms when a finite form would be required by the adult grammar (see examples 5 to 7 below).

5) *Pas attraper papillon (Daniel, 1;8.3; Lightbown, 1977)

Not catch-INF butterfly

Not catch butterfly

6) *Hubschrauber putzen (Andreas; 2;1; Wagner, 1985)

Helicopter clean-INF

Clean helicopter

7) *Pappa bära den (Markus, 1;11.12; Plunkett and Strömquist, 1992)

Daddy carry-INF it

Daddy carry it

In each of these cases, the verb is marked with an infinitival morpheme: –*er* (French (Deprez & Pierce, 1993)), -*en* (German (Poeppel & Wexler, 1993)) and –*a* (Swedish (Josefsson, 2002)), and the error therefore cannot be explained in terms of inflection drop.

This pattern of errors has led to the view that problems in verb marking across languages (including the incorrect use of zero-marked forms in English) reflect the use of non-finite forms when a finite form would be required by the adult grammar. Since these errors tend to occur during a stage in which the child is also producing correct finite forms, they are often referred to in the literature as Optional Infinitive (OI) errors and the period during which they occur as the Optional Infinitive stage. Since children with DLD tend to make OI errors at later ages and at higher MLUs than typically developing children, the period during which these children make OI errors is sometimes referred to as the Extended Optional Infinitive Stage.

The Verb-Marking Deficit in Children with DLD

The term Developmental Language Disorder is used to refer to ‘a significant deficit in language ability that cannot be attributed to hearing loss, low non-verbal intelligence or neurological damage’ (Leonard, 2014: 3). Children with this kind of developmental profile were previously referred to in the literatue as children with Specific Language Impairment (SLI). However, in recent years, a new consensus has emerged in favour of the term Developmental Language Disorder (see Bishop, Snowling, Thompson, Greenhalgh & the CATALISE-2 consortium, 2016; 2017). Developmental Language Disorder is therefore the term that we will use in the present study.

According to Tomblin, Records, Buckwalter, Zhang, Smith and O’Brien (1997), children with Developmental Language Disorder make up approximately 7% of the preschool-aged population. They are not a homogeneous population (Leonard, 2014), and may show deficits in a number of different language domains, including phonology, word learning, morpho-syntax and pragmatics (Kauschke, 2012). However, they tend to show a particular deficit in the use of verb morphology. For example, Rice, Wexler & Hershberger (1998) describe a group of English-speaking children with DLD who show significant deficits in 3sg present and past tense marking relative to both age-matched and language-matched controls and Rice et al. (1997) describe a group of German-speaking children with DLD who make significantly more OI errors than a group of MLU-matched controls. This verb-marking deficit tends to be taken by generativist researchers such as Rice et al. to reflect a biologically based deficit in the child's underlying grammar. However, the alternative constructivist view is that it reflects a processing deficit that affects the way in which the child analyses the input language. A key aim of this paper is to differentiate between these two possibilities by testing the predictions of the generativist Extended Optional Infinitive hypothesis (Rice & Wexler, 1996; Rice et al., 1995) and the constructivist Dual-Factor Model (Freudenthal et al., 2010; 2015a) on a group of German-speaking children with DLD and a group of typically developing language-matched controls.

The Extended Optional Infinitive Hypothesis

The Extended Optional Infinitive (EOI) Hypothesis is built on the assumption that the tendency of German-speaking children to produce infinitives when a finite form is required by the adult grammar reflects a biologically based maturational difference between the child and the adult grammar. This difference persists for longer and extends further up the MLU range in children with DLD.

According to the EOI hypothesis, the pattern of verb-marking error in both English- and German-speaking children reflects the fact that, although they have correctly set all the inflectional and clause structure parameters of their language from a very early age, there is a developmental stage (the OI stage), during which they are subject to a Unique Checking Constraint (UCC), which competes with other constraints in the child's grammar to result in the optional use of finite and non-finite forms in finite contexts. The UCC withers away gradually over the course of development, and does so more slowly in the grammars of children with DLD. Children with DLD are therefore subject to an extended OI stage in which they produce OI errors at significantly higher rates than both age-matched and language-matched controls.

The great strength of the EOI hypothesis is that it provides an integrated cross-linguistic account of the pattern of verb-marking error in both typically developing children and children with DLD. First, it can explain why children learning obligatory subject languages such as English and German make OI errors at substantially higher rates than children learning INFL-licensed null subject languages such as Italian and Spanish (Wexler, 1998). Second, it can explain why children with DLD learning English and German tend to make OI errors at higher rates than MLU-matched controls (Rice et al. 1998; Rice et al., 1997). And, third, it can explain why other kinds of verb-marking errors are rare in children's speech. For example, it can explain why German-speaking children tend to correctly place finite forms before and infinitive forms after their complements (Poeppel & Wexler, 1993), and why subject-verb agreement errors such as '*I goes' are rare across languages (Harris & Wexler, 1996; Hoekstra & Hyams, 1998).

Despite these strengths, the EOI Hypothesis also suffers from a number of weaknesses. First, although it correctly predicts a verb-marking deficit in both English- and German-speaking children with DLD, it has little to say about differences in the size of this deficit. Moreover, this is despite the fact that the verb-marking deficit in English appears to be much larger than the verb-marking deficit in German. Thus, although both Rice et al., (1995) and Rice et al., (1998) report differences between English-speaking children with DLD and MLU-matched controls until late in development, the MLU-matching effect in Rice et al.'s (1997) German data appears to be relatively short-lived, with both the DLD group and the language-matched controls only producing OI errors with any frequency at the first of their two measurement points. The implication is that German-speaking children with DLD may only produce high rates of OI errors at low MLUs, and hence that there may be a difference in the nature of the verb-marking deficit in English- and German-speaking children with DLD that the EOI hypothesis cannot explain. List and Pine (in press) provide further evidence in support of this conclusion in a case study of a German-speaking child with DLD, who produced very few OI errors once his MLU in words had risen above 2.2.

Second, although verb-positioning and subject-verb agreement errors appear to be rare in the speech of typically developing German-speaking children – and Rice et al. (1997) also report very few of these errors in the speech of their German-speaking children with DLD – other studies of German-speaking children with DLD have reported different results. For example, Dannenbauer and Kotten-Sederqvist (1990) and Hamann, Penner and Lindner, 1998) describe German-speaking children with DLD who produce non-finite forms in second position and finite forms in utterance-final position position, and Clahsen, Bartke and Göllner (1997) report both verb-positioning and agreement errors in their German DLD data. Similarly, Rothweiler, Chilla and Clahsen (2012) report problems with the production of correctly agreeing verb forms in a group of German-speaking children with DLD and a group of Turkish-German bilingual children; and List & Pine (in press) report both verb-positioning and agreement errors in their German DLD case study. These results are clearly at odds with Rice et al.'s (1997) findings, and Rothweiler et al. (2012) note that one possible reason for the discrepancy, at least with respect to agreement errors, is that Rice et al. restricted their agreement analysis to just two affixes, 3sg *-t* and 2sg *-st* and thereby *"*reduced the chances of finding agreement errors*"* (Rothweiler et al. 2012: 52).

Third, because the EOI hypothesis assumes that OI errors reflect the optional use of non-finite forms in finite contexts, it predicts that OI errors and correct finite forms will occur in free variation in children's speech. However, there is now a great deal of evidence that OI errors and correct finite forms tend to occur in complementary distribution in modal and non-modal contexts and with semantically different sets of verbs. These semantic conditioning effects have been reported in a number of OI languages, including Dutch (Jordens, 1990; Wijnen, 1998); French (Ferdinand, 1996); Swedish (Josefsson, 2002), and, most importantly in the current context, Germam (Ingram & Thompson, 1996). List and Pine (in press) also show that they can be seen in the speech of a German-speaking child with DLD, who was significantly more likely to produce OI errors with eventive than with stative verbs.

For the purposes of the present study, the EOI hypothesis makes three predictions about the pattern of verb-marking error in the speech of children with DLD and MLU-matched controls. First, since OI errors are assumed to reflect the operation of a single underlying factor that extends higher up the MLU range in children with DLD, the EOI hypothesis predicts that children with DLD will show deficits relative to MLU-matched controls in both modal and non-modal contexts. Second, since OI errors and correct finite forms are assumed to occur in free variation in children's speech, the EOI hypothesis predicts that German-speaking children (both children with DLD and typically developing controls) will make OI errors at similar rates in modal and non-modal contexts. Third, since OI errors are assumed to reflect a difference at the level of the underlying grammar, as opposed to differences in children's knowledge about particular verbs, the EOI Hypothesis predicts no relation between the rate at which either children with DLD or language-matched controls will produce OI errors with particular verbs and the rate at which those verbs occur in infinitive as opposed to finite form in German child-directed speech.

The Dual-Factor Model

The Dual-Factor Model is built on the assumption that the pattern of verb-marking error in early child German reflects two different processes. The first is the learning of OI errors from modal (compound-finite) structures in the input (e.g. 'Mama will einen Turm bauen' (Mummy wants a tower build-INF) and 'Papa kann ein Auto zeichnen' Daddy can a car draw-INF)). The second is a process of defaulting to the form of the verb with which the child is most familiar when the correct form of the verb is only weakly represented in the child's system. As the child's ability to process verbs that occur earlier in the sentence is assumed to increase with MLU, the verb form with which the child is assumed to be most familiar is initially the infinitive, which is more frequent in short utterance-final sequences than the most frequent finite form, and only later the third person singular present tense –t form, which is the most frequent form in the input as a whole (Freudenthal et al., 2015a and in prep.).

The Dual-Factor Model is based on a computational model of the OI stage: MOSAIC, which simulates the developmental patterning of finiteness marking in several different languages. MOSAIC simulates OI errors because it has a strong utterance-final bias in learning. In older versions of MOSAIC OI errors like 'go there' where also learned from questions e.g. 'Does that go there?'. Freudenthal and colleagues mentioned a weak utterance-initial and a strong utterance-final bias first in 2010, which enables MOSAIC to learn from both edges of the utterance. The new version of the model represents utterance-internal omission errors as concatenations of utterance-initial and utterance-final strings, which makes it possible to produce OI errors with subjects in declaratives (e.g. He _ go there) and OI errors in Wh- questions (Where _ he go?) (Freudenthal et al., 2015). These biases result in the learning of OI errors from utterances that contain a (finite) modal and an infinitive (e.g. '*Mama Turm bauen' (Mummy tower build-INF) from 'Mama will einen Turm bauen' and '*Papa Auto zeichnen' (Daddy car draw-INF) from 'Papa kann ein Auto zeichnen'). MOSAIC simulates the developmental patterning of OI errors because, as the average length of its utterances increases, these utterances are increasingly likely to include finite modals, with the result that the OI errors in MOSAIC's output are slowly replaced by the longer structures from which they were originally learned.

Initial work using MOSAIC showed that the idea that OI errors were learned from compound-finite structures could explain the cross-linguistic patterning of errors in Dutch, English, German and Spanish (Freudenthal, Pine & Gobet, 2006; Freudenthal, Pine, Aguado-Orea & Gobet, 2007). However, the English simulations in these studies focused only on utterances with overt third person singular subjects. In a later study, Freudenthal and colleagues (2010) showed that, when utterances with missing subjects were included in the analysis, MOSAIC was unable to simulate the very high rates of OI errors in early child English. Freudenthal et al. (2010) therefore argued for a Dual-Factor Model in which MOSAIC's basic learning mechanism was supplemented by an additional defaulting mechanism. This mechanism results in the substitution of the form of the verb with which the child is most familiar when the correct form of the verb is only weakly represented in the child's system. In English, this form is assumed to be the bare stem since this is the most frequent form of the verb regardless of sentence position. In German, this form is assumed to be the infinitive at low MLUs and the third person singular present tense –t form at high MLUs, since the infinitive tends to be the most frequent form of the verb in short utterance-final strings and the third person singular present tense –t form tends to be the most frequent form of the verb in the input as a whole.

According to the Dual-Factor Model, German OI errors in modal contexts reflect the learning of bare infinitives from modal (compound-finite) structures in the input and reflect the child's limited processing ability (as indexed by MLU). However, at low MLUs, German-speaking children will also make OI errors in non-modal contexts by defaulting to the infinitive. In German the rate at which both types of errors occur is tied to MLU because, although defaulting at low MLUs tends to result in OI errors, defaulting at high MLUs tends to result in agreement errors (i.e. errors in which the child defaults to the most frequent finite form which is the third person singular present tense –t form). Note that defaulting to the infinitive in non-modal contexts is also likely to result in verb-positioning errors since, in German, finite verbs occur in verb-second position, whereas infinitives occur in utterance-final position. Substituting infinitives for finite forms is therefore likely to result in verb-positioning errors in which infinitives occur before rather than after their complements (e.g. '*Mama bauen Turm' (Mummy build-INF tower).

The Dual-Factor Model has so far only been used to simulate data on typically developing children. However, there is evidence that both of the mechanisms incorporated in the model are also operative in English-speaking children with DLD. Thus, Leonard and his colleagues provide evidence that OI errors in English-speaking children with DLD reflect the inappropriate extraction of non-finite subject-verb sequences from more complex structures in the input (e.g., Leonard & Deevy, 2011; Leonard, Fey, Deevy & Bredin-Oja, 2015), and Kueser, Leonard and Deevy (2018) show that English-speaking children's tendency to produce bare forms in 3sg elicitation contexts is significantly correlated with the relative frequency with which particular verbs occur as bare rather than 3sg present tense forms in English child-directed speech. The Kueser et al. (2018) study replicates the results of a previous study of typically developing children by Räsänen, Ambridge and Pine (2014) on a group of children with DLD and a group of language-matched controls, and shows that the children with DLD also produced significantly more bare forms in 3sg contexts than the typically developing children.

When taken together, these results suggest that the Dual-Factor Model may be able to account for the pattern of verb-marking error in English-speaking children with DLD. However, it is unclear whether the model can also account for the pattern of verb marking error in German-speaking children with DLD (though see Chapter 5 for some preliminary evidence that is broadly consistent with this view).

For the purposes of the present study, the Dual-Factor Model makes three predictions about the pattern of verb-marking error in the speech of German-speaking children with DLD and MLU-matched controls. First, since, in German, the rate at which OI errors occur in both contexts is tied to MLU, the Dual-Factor Model predicts no difference in the rate of OI errors between children with DLD and MLU-matched controls in either context. Second, since the principal source of OI errors in German is assumed to be the learning of infinitives from modal structures in the input, the Dual-Factor Model predicts that both children with DLD and typically developing children will produce OI errors at higher rates in modal than non-modal contexts. Third, since defaulting errors are assumed to reflect differences in children's knowledge about particular verbs, the Dual-Factor Model predicts a significant correlation between the rate at which both children with DLD and MLU-matched controls will produce defaulting errors (i.e. OI errors in non-modal contexts) on particular verbs and the rate at which those verbs occur in infinitive as opposed to finite form in German child-directed speech.

The present study

Our goal in this study was to contrast two competing theoretical accounts of OI errors in German. The generativist EOI account (Rice et al., 1995; 1997; Rice & Wexler, 1996) assumes that the core deficit in DLD is an extension of the OI stage shown by typically developing children. The EOI account therefore predicts that children with DLD will show higher rates of OI errors than MLU-matched typically developing (TD) controls in both modal and non-modal contexts. Context is not relevant because, under this account, non-finite forms are produced solely because during the (extended) OI stage, tense marking is optional in the child grammar. As a consequence of this assumption, the EOI account does not predict any effect of the input-bias predictor, for either the DLD or TD groups.

The constructivist Dual-Factor Model (Freudenthal et al., 2010; 2015a) assumes that, although both are tied to MLU, OI errors have different sources in modal and non-modal contexts. In modal (compound-finite) contexts, such errors reflect simple omission of the modal auxiliary (**Lisa [kann] eine Blume malen – Lisa [can] a flower paint-INF*), yielding an OI error with characteristic verb-final word order. As storage and retrieval capacity increase with development, as indexed by increasing MLU, these errors will disappear. That is, in broad-brush terms, a child at MLU=4 can say only **Lisa eine Blume malen*, but when she reaches MLU=5, can say *Lisa kann eine Blume malen*.

In non-modal (simple-finite) contexts, OI errors reflect “defaulting” (Räsänen et al., 2014): substitution of the non-finite form (e.g., *malen,* ‘paint-

INF') for the simple-finite form (e.g., *malt*, 'paints')[5]. Unlike in English (e.g., Räsänen et al., 2014; Kueser et al., 2018), this defaulting is not driven solely by simple frequency. Indeed, for most verbs, the non-finite *-en* form is *less* frequent than the simple finite 3sg *-t* form[6]. For German, this defaulting effect is assumed, at least in part, to reflect the fact that *-en* forms are considerably more frequent than 3sg *-t* forms *in short utterance-final sequences* (e.g., *Lisa kann eine Blume <u>malen</u>* vs *Lisa <u>malt</u> ein Blume*). Thus, given the Dual-Factor Model's right-edge learning bias, children with low MLUs are argued to store non-finite *-en* forms considerably more often than simple finite 3sg *-t* forms. Again, as storage and retrieval capacity increase with development, as indexed by increasing MLU, these errors will disappear. That is, in broad-brush terms, a child at MLU=1 has stored only *malen*, but when she reaches MLU=3 can store *malt eine Blume*.

Since the Dual-Factor Model assumes that OI errors in both modal and non-modal contexts are tied to low MLU, this account predicts that – because the DLD and TD groups have been matched for MLU – they will not differ in the rates of OI errors produced, in either non-modal or modal contexts. This

[5]The Dual-Factor Model would also seem to predict that, when children produce OI errors via this route, they will use the verb-second (V2) word order that is reserved for finite verb forms (e.g., **Lisa malen eine Blume*) rather than non-finite verb-final word order (e.g., **Lisa eine Blume malen*). In fact, very few such errors were observed in the present study (only 16 of the 157 OI errors produced in non-modal contexts). This is potentially problematic for the Dual-Factor Model. However, one way to solve this problem would be for the Dual-Factor Model to posit that when children at low MLUs are storing non-finite forms (e.g., malen), they are alsosomehow noticing and storing the fact that they tend to occur in utterance-final position.

[6] Although such forms are homophonous with 1pl and 3pl finite forms (e.g. *wir malen*, "we paint"; *sie malen*, "they paint"), these finite forms are considerably outnumbered in the input by true non-finite forms.

prediction is in sharp contrast to that of the EOI model, which, as we have already seen, predicts that the DLD group will produce more OI errors than the TD group in both modal and non-modal contexts.

Since the Dual-Factor Model assumes that the principal source of OI errors in German is the learning of these errors from modal structures in the input, a second prediction of this account is that both children with DLD and typically developing children will produce OI errors at higher rates in modal than non-modal contexts. This prediction is in sharp contrast to that of the EOI model which, as we have already seen, predicts no difference between the rate of OI errors observed in modal versus non-modal contexts (for either the DLD or TD group).

Finally, because the Dual-Factor Model sees OI defaulting errors in non-modal contexts as driven by the relative frequency of infinitive and finite forms in short utterance-final sequences, this account also predicts an effect of input frequency (i.e., of the relative frequency of infinitive *-en* versus 3sg *-t* forms). It predicts no such input effect in modal contexts, where such errors are taken to reflect simple omission of the modal. Again, this prediction is in sharp contrast to that of the EOI model, which, as we have already seen, predicts no input effect for either condition.

6.2 Methods

Ethics statement

This study was approved by the University of Liverpool Ethics Committee and by the Max Planck Institute for Evolutionary Anthropology Child Subjects Committee in Leipzig, Germany. Informed written consent was obtained from the schools and caregivers, and the children gave verbal consent.

Participants

An initial sample of 129 children (from Leipzig and Berlin) were tested and assigned to either the group of DLD children (final *N*=32) or to the group of younger MLU-matched typically-developing (TD) controls (final *N*=32), with non-qualifying children, according to the criteria described below, excluded (N=65). See Appendix E for an overview of the exclusion process of tested participants. 125 children were recruited through the Max Planck Institute for Evolutionary Anthropology from 25 nurseries in Leipzig and 4 children were recruited through an SLT practice in Berlin. All children were monolingual speakers of German and had no history of hearing problems and no other disorders that could have caused problems with language (e.g. Down Syndrome, ADHD, neurological dysfunction).

Group (DLD/TD) was assigned using subtests from the Patholinguistische Diagnostik bei Sprachentwicklungsstörungen 2nd Edition (PDSS) (Kauschke & Siegmüller, 2009) and from the Sprachentwicklungstest für Kinder (SETK) (Grimm, 2016, 2015). Children scoring below 35 on both verb production (PDSS) and sentence comprehension (SETK) were assigned to the DLD group (this corresponds to 1.5 standard deviations below the mean for the published norms). PDSS subtests measuring noun and verb comprehension were administered but were treated solely as an additional measure of vocabulary, and not used for group assignment. Because the children in the MLU-matched TD control group were too young for the published norms to apply, we instead adopted our own criteria: In order to be included in this group, children had to score no lower than 1.33 SDs below the mean score for the group.

In order to ensure that the DLD and TD groups were broadly matched for non-verbal IQ, we also administered the non-verbal part of the *Kaufman Assessment Battery for Children Second Edition* (KABC-II; Kaufman & Kaufman, 2015). Even though the KABC-II is not standardized for the younger typically developing age group, the TD and DLD groups had very similar means (average IQ 91, SD=11.66 vs. 92.81, SD=12.77). Following recent recommendations that “children with DLD may have a low level of non-verbal ability” (Bishop et al., 2017: 1072), we did not exclude children from the DLD group on the basis of their IQ scores.

The final DLD group consisted of 32 children (7 females) aged 3;2 to 5;08 (*M* = 4;1, SD = 8.1 months), with a Mean Length of Utterance (MLU) of 3.09 (SD = 0.68). The final MLU-matched control group consisted of 32 children (17 females) aged 2;3 to 2;11 (M = 2;6, SD = 2,4) with an MLU of 3.09 (SD = 0.50). MLU scores (in words) were derived from a spontaneous language sample (as described below). One child from each group did not take part in this session; therefore, the mean MLU (across all children) was used for these children in the analysis. To match the groups for MLU, 15 children from the TD group with MLU lower than 2.4 were excluded and 7 children from the DLD group with MLU higher than 4.0 were excluded, yielding the final sample of *N*=32 per group.

Design and materials

The study consisted of a verb elicitation experiment with two different conditions: non-modal (simple-finite; e.g., *Lisa malt eine Blume – Lisa paints a* *flower*) and modal (compound-finite; e.g., *Lisa kann eine Blume malen – Lisa can a flower paint-INF*). The planned dependent variable was the number of correct verb forms (either *3sg -t* or *modal* + *infinitive,* depending on condition) versus OI errors (with all other responses excluded as missing data). However, as we will see shortly, the fact that missing responses were not missing at random raises doubts about the reliability of this measure.

In each condition, 30 prompt sentences with different verbs (see Appendix F) were presented alongside pictures of two children, using a laptop computer. Following Räsänen et al. (2014) and Kueser et al. (2018), verbs were selected on the basis that, in the input portion of the Leo corpus (Behrens, 2006) they were strongly biased to occur in either 3sg -t or non-finite -en form (the bias measure is described below). Verbs were also chosen to be high frequency, unambiguous and easy to illustrate in pictures (Figure 10). Both conditions had the same set of 30 verbs (e.g., *Lisa kann einen Turm bauen – Lisa can a tower build-INF; Lisa baut einen Turm – Lisa builds a tower*), which were presented in randomized order within each condition block (modal/non-modal).

Before the experiment started, the researcher introduced a story featuring two children, Lisa and Peter, to the participant. These warm-up sentences also served to introduce the two conditions (e.g., Jeden Tag macht Peter etwas – *Every day Peter does something vs. Jeden Tag kann Peter etwas machen – Every day Peter can do something*). Then two practice trials followed, in which, if necessary, the researcher prompted the child and/or gave the correct answer for the child to repeat.

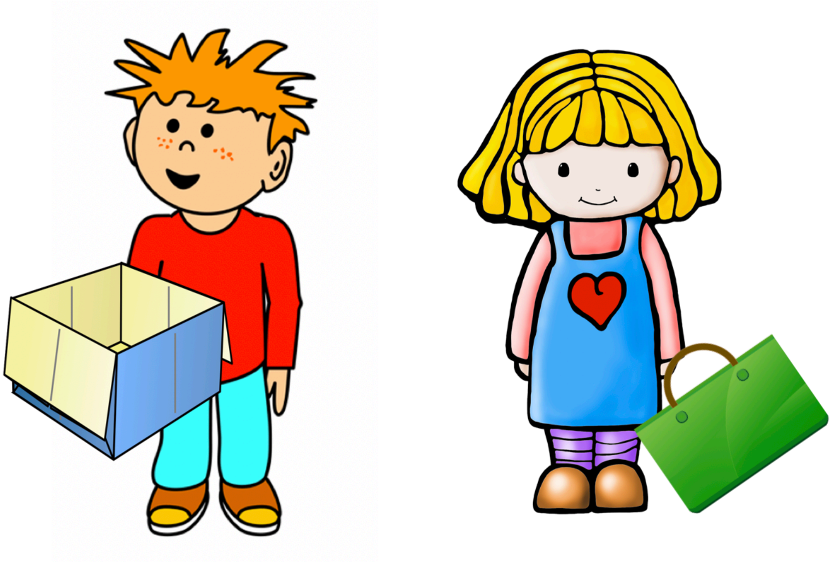

Figure 10: Example context for 'Carry' taken from the elicitation experiment. (a) "Peter trägt eine Box. Lisa… – Peter carries a box. Lisa…" b) "Peter kann eine Box tragen. Lisa… – Peter can a box carry-INF. Lisa…")

Each of the 30 trials, as well as the two practice trials, consisted of a prompt sentence for children to complete with the help of the illustrations on the laptop screen (e.g. non-modal condition: *Lisa fährt ein Auto – Lisa drives a car. Peter …*; modal condition: *Lisa kann ein Auto fahren – Lisa can drive a car. Peter…*). Every sentence started with a two-syllable word, which was always the name of one of the characters (*Lisa or Peter*). In every target clause, the verb was followed by a two- or three-syllable phrase (e.g., *ein Buch – a book; ein Bagger – a digger*). Wherever possible, this phrase began with a vowel (usually the word ein – *a*), in order to allow us to identify easily whether or not children produced the 3sg *-t* ending in the non-modal (simple-finite) condition. The order in which each condition was presented to the children was random.

Procedure

Each child was tested individually in a quiet setting, with each session lasting approximately 30-45 minutes, depending on the child. Testing was divided into two sessions on different days. All sessions were audio recorded with a Dictaphone and additionally with Audacity (running in the background of the laptop used for the experiment). During the recordings, the researcher took care not to use the child's name.

On Day 1, children completed three subtests from the PDSS, two subtests from the KABC-II and 30 trials from the main study, constituting either the modal or non-modal condition (counterbalanced across children). On Day 2, children completed the remaining two subtests from the KABC-II, the single remaining subtest from the SETK, and the remaining condition (30 trials) from the main study. Finally, the researcher introduced a standard set of toys (a wooden farmhouse and animals) to use for play and interaction while collecting the spontaneous speech sample for calculating MLU. The researcher described the ongoing play, and encouraged the child to do the same, for 15 to 20 minutes.

Transcription, scoring and reliability

The play sessions were recorded and transcribed offline in CHAT format (MacWhinney, 2000), and MLU in words was calculated using CLAN (MacWhinney, 2000). Responses from the experiment were transcribed during testing and checked afterwards using the audio recordings. Responses were coded as (1) correct, (0) OI – Optional Infinitive or (NA) unscorable, as described below.

(1) Correct (N=1521): The child produced (a) 3rd person singular *-t* with the target verb in the non-modal (simple-finite) condition or (b) the modal *can* and the target verb in non-finite form in the modal (compound-finite) condition (e.g., *Lisa malt eine Blume – Lisa paints a flower; Lisa kann eine Blume malen – Lisa can paint a flower*). The OBJECT (e.g., a flower) did not have to be correctly produced for the utterance to be scored as correct (or as an OI error)

(0) OI – Optional Infinitive (N=420): The child produced the target verb in non-finite form, in either condition (e.g., **Lisa Blume malen-INF – Lisa paint a flower*). In order to be classified as an OI, the non-finite form did not have to be produced in final position (as in the example above); non-finite forms in verb-second position (e.g. **Lisa malen Blume*) were also classified as OI errors, although, in practice, very few utterances of this latter type were produced.

(NA) Unscorable (N=1899): The child produced (a) no response or an unintelligible response, (b) a non-target verb, (c) the target verb with the modal *kann* in the simple-finite condition, (d) the target verb with 3rd person singular *-t* in the modal condition, (e) only the modal *kann*, or (f) some other response or no response. See Appendix G for an analysis of error rates. Although the proportion of unscorable responses (49.5%) is relatively high, many of these answers were pragmatically appropriate in context (e.g. “Lisa buys an apple. Peter…”, child answers “an orange”), an issue to which we return in the Discussion). The proportion of unscorable responses is not unexpected given the experimental design, in which children are free to produce any response, and is similar to that observed in comparable studies (e.g., Tatsumi, Ambridge & Pine, 2018; Räsänen et al., 2014; Kueser et al., 2018).

A significant concern, however, is that these missing data were not missing at random. Rather, a large negative correlation (r= -0.53, p=0.003) was observed between verbs' input bias towards finite (3sg *-t*) versus non-finite (*-en*) form and the number of valid responses (i.e., correct + OI forms) produced by the children. In other words, verbs that are heavily biased towards appearing in finite (3sg *-t*) form (e.g., *geben, kriegen*, *schmecken*) tend to be avoided (in both the modal and non-modal conditions). This is highly problematic in terms of theory testing, since these are exactly the verbs predicted, under the Dual-Factor Model, to show low rates of OI error and high rates of correct 3sg *-t* inflection in non-modal contexts. However, if this pattern is observed, there is no way to tell whether it constitutes support for the Dual-Factor Model, or whether it simply reflects the fact that only children who are very confident at 3sg *-t* inflection even attempt the trials in question. The possible reasons for this unexpected finding, and its implications for the ability of the study to test the hypotheses under investigation, are considered in more detail below.

In order to calculate reliabilities, 10% of the responses from the experiment were transcribed independently by a native German speaker blind to the hypotheses under investigation. Inter-rater reliability was high at 92% agreement (Cohen's Kappa = .86).

Analyses

Predictor variables were condition (non-modal (simple-finite)/modal (compound-finite)), group (DLD/TD), MLU, vocabulary (both as control predictors) and a predictor reflecting the relative frequency of each verb in 3sg -t versus infinitive -en form in the child-directed speech sample of the Leo corpus (Behrens, 2006). For example, the bias towards the finite form for the verb ‘bauen – build’ (Table 9) was calculated from the token count of finite 3sg –t and infinitive forms of this verb (baut – builds and bauen – build) and those of all other verbs in the data following the formula:

$$\chi 2 = (ad-bc)2*(a + b+c + d)/(a + c)(c + d)(b + d)\ (a + b).$$

As in previous studies (e.g., Tatsumi et al., 2018), we used a chi-square statistic, which represents the extent to which the particular bias towards the finite form (finite 3sg –t versus infinitive) for ‘bauen – build’ differs from the bias shown by all other verbs in the input (see Tatsumi et al., 2018 for details).

Table 9: Contingency table for the calculation of chi-squares (example: bauen – build)

	Target verb	All other verbs	Row totals
Finite 3sg –t form	a (112)	b (56863)	a+b
Infinitive form	c (348)	d (26584)	c+d
Column totals	a+c	b+d	a+b+c+d

The chi-square values were natural-log transformed (ln(1 + n)) and polarity (+/–) set to indicate whether a verb is biased towards finite or non-finite form, as is standard for this type of measure (see, e.g., Gries, 2015).

Although the measure is not based on the individual participants’ input (which is not available), our assumption is that it constitutes a reasonable approximation to the general by-verb distribution of finite versus non-finite forms in child-directed speech. The finding that participants’ behaviour is predicted by the frequency of items in a corpus of data that does not represent their individual input is well established for both adults and children (e.g., Bannard & Matthews, 2008); see Ambridge, Rowland, Theakston, & Kidd, (2015) for a review.

6.3 Results

Figure 11 summarizes the responses for the DLD and MLU-matched TD control group. Visual inspection of this figure suggests possible support for the prediction of the EOI hypothesis that the DLD group will show a higher overall rate of OI errors than the TD group (the Dual-Factor account predicts no difference). On the other hand, the figure suggests possible support for the predictions of the Dual-Factor Model that (a) both groups will show more OI errors in the modal than non-modal condition and (b) an effect of the chi-square input-bias measure will be observed in the non-modal condition only.

In order to investigate these predictions in more detail, we ran a series of mixed effects regression models. However, it is important to bear in mind at the outset that these findings should be considered tentative given that missing data responses were missing not at random, but in a way that could plausibly yield spurious support for the predictions of the Dual-Factor Model (particularly the prediction of an input effect in the non-modal condition).

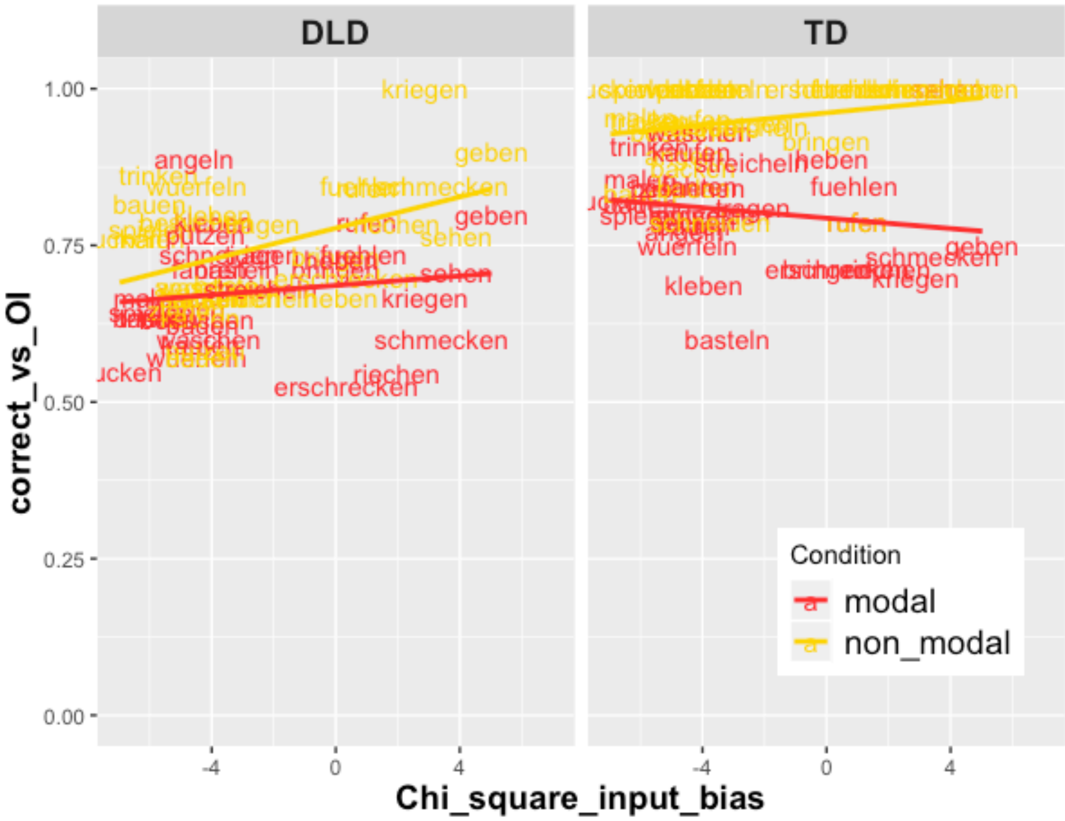

Figure 11: Mean proportion of correct responses (vs OI errors) for the DLD and TD groups as a function of condition (modal/non-modal) and the chi-square input-bias predictor (higher values indicate a greater proportion of occurrences with 3sg -*t*)

The data were analysed in RStudio (version 1.1.463; R version 3.5.3, R Core Team, 2018). As the dependent variable was binary (correct/OI, with other responses treated as missing data), results were analysed using the glmer function of the lme4 package (version 1.1-17, Bates, Maechler, Bolker & Walker, 2015) with the bobyqa optimizer. Predictor variables were MLU, vocabulary, the chi-square input-bias predictor, group (DLD coded as 0 / TD coded as 1) and condition (modal coded as 0 / non-modal coded as 1). The model included random intercepts for verb (item) and participant and a by-participant random slope for the chi-square input-bias predictor (e.g., Barr, Levy, Scheepers, & Tily, 2013). The introduction of any further random slopes caused convergence failure.

Since all models were binomial, we report *p* values calculated on the basis of the z distribution (output by default from the glmer function of lme4). None of the other popular methods for calculating *p* values (see Luke, 2017 for details) could be used in this case: (1) MCMC sampling is not implemented for models with random slopes. (2) Methods that rely on comparing nested models (likelihood ratio test; Kenward–Roger approximation) do not allow for the removal of a simple main effect while retaining interaction terms for that variable. (3) The Satterthwaite degrees of freedom method (lmerTest package; Kuznetsova, Brockhoff & Christensen, 2017) is not applicable for binomial models. (4) Parametric bootstrapping (found by Luke, 2017, to be the most conservative) is not compatible with the bobyqa optimizer, without which, even a model with random intercepts but no random slopes failed to converge. In any case, there is no reason to believe that the method we used is anticonservative: Since, for binomial models, lme4 outputs *z* values directly, *p* values can legitimately be taken from the *z* distribution, without the potentially problematic step – required for models with a continuous dependent variable – of treating the Wald *t* value as if it were a *z* value (the *t* and *z* distributions are identical only with an infinite sample size).

We first built a full model including all three predictors of interest, group (DLD/TD), condition (modal/non-modal), and the chi-square input-bias predictor, as simple main effects and in all interactions, and the control predictors, MLU and vocabulary, as simple main effects only.

Table 10: Mixed effects model for all German data

Parameter	Coefficient	SE	CI_low	CI_high	z	p
(Intercept)	-7.51	2.42	-12.25	-2.77	-3.10	0.002
MLU	**2.27**	**0.67**	**0.96**	**3.57**	**3.40**	**0.001**
Vocabulary	0.05	0.04	-0.02	0.12	1.44	0.148
Input bias	-0.03	0.06	-0.14	0.08	-0.54	0.588
group	-0.06	1.08	-2.18	2.05	-0.06	0.952
Condition	**1.02**	**0.34**	**0.35**	**1.69**	**2.97**	**0.003**
Input bias x group	0.02	0.08	-0.14	0.17	0.20	0.839
Input bias x condition	0.03	0.08	-0.12	0.19	0.39	0.699
Group x condition	**1.38**	**0.58**	**0.24**	**2.52**	**2.37**	**0.018**
Input bias x group x condition	0.10	0.13	-0.16	0.36	0.78	0.437

The model (see Table 10) revealed a significant simple main effect for the control predictor MLU, which highlights the importance of including MLU as control predictor in the analysis. With regard to the theoretical predictions under investigation, the analysis did not provide support (*p*=0.95) for the prediction of the EOI account that, collapsing across condition (modal/non-modal), the DLD group will produce a lower proportion of correct forms (M=0.71, SD=0.46), and hence a higher-rate of OI errors, than the TD group (M=0.87, SD=0.33). However, given that this is a between-subjects comparison and a relatively small (if not untypical) sample size, this finding certainly cannot be taken as evidence for the null hypothesis of no difference between the groups, or as evidence against the EOI account.

The model also revealed a significant simple main effect of condition (p=0.003), such that, as predicted by the Dual-Factor Model, collapsing across group (DLD/TD), children produced a higher proportion of correct forms in non-modal (*M*=0.83, *SD*=0.37) than modal contexts (*M* =0.74, *SD* =0.44). However, the observed interaction ($p<0.05$) of group (DLD/TD) by condition (modal/non-modal) suggests that both the EOI and Dual-Factor accounts are incorrect in predicting that the effect of condition will not vary by group (i.e., the EOI account predicts that *neither* group will show an effect of condition; the Dual-Factor account predicts that *both* groups will show an effect of condition). This interaction is investigated in separate by-condition analyses below, which also test the prediction of the Dual-Factor Model that an input effect will be observed for the non-modal condition only (albeit that the interaction of input by group was not significant)

Submodels by condition

In order to better understand the interaction described above, we ran separate models for the modal (compound-finite, Table 11a) and non-modal (simple-finite, Table 11b) conditions. In order to enable model convergence, the predictor of vocabulary and the by-participant random slope for the chi square input-bias predictor were removed.

Table 11a: Mixed effects model for modal condition

Parameter	Coefficient	SE	CI_low	CI_high	z	p
(Intercept)	-8.33	2.94	-14.10	-2.57	-2.83	0.005
MLU	**3.01**	**0.93**	**1.18**	**4.84**	**3.22**	**0.001**
Input bias	-0.02	0.05	-0.13	0.08	-0.45	0.653
Group	1.44	1.08	-0.67	3.55	1.34	0.181
Input bias x group	0.02	0.08	-0.13	0.18	0.26	0.791

Table 11b: Mixed effects model for non-modal condition

Parameter	Coefficient	SE	CI_low	CI_high	z	p
(Intercept)	-7.37	6.78	-20.65	5.91	-1.09	0.277
MLU	**4.43**	**1.97**	**0.57**	**8.29**	**2.25**	**0.024**
Input bias	0.05	0.09	-0.13	0.23	0.57	0.567
Group	3.37	2.11	-0.77	7.51	1.60	0.11
Input bias x group	0.13	0.19	-0.24	0.50	0.68	0.498

In each of the separate models, MLU was the only significant effect. The lack of an effect of group (DLD/DLD) is more consistent with the predictions of the Dual-Factor than the EOI model, while the lack of an effect of the input-bias predictor (particularly in the non-modal condition) is more consistent with the predictions of the EOI than the Dual-Factor Model. That said, it is important not to take the absence of a significant effect as strong positive evidence for a null effect in the absence of a Bayesian analysis or frequentist equivalence testing (Dienes, 2014). In fact, we did not proceed with such an analysis because, as noted above, the findings are already seriously called into question by the fact that missing data were missing not at random, but in a manner that correlates with the input-bias predictor.

Nevertheless, before proceeding with an analysis of avoidance effects, we ran separate models for the DLD (Table 12a) and TD (Table 12b) groups, in order to examine the prediction of the Dual-Factor Model that both groups will show more OI errors in the modal than non-modal condition. Recall that the EOI model predicts no effect of condition (modal/non-modal) for either group (though it is important to bear in mind the caveat just raised regarding null results).

Table 12a: Mixed effects model for DLD children

Parameter	Coefficient	SE	CI_low	CI_high	z	p
(Intercept)	-6.73	3.49	-13.58	0.12	-1.93	0.054
MLU	**2.65**	**1.14**	**0.42**	**4.89**	**2.33**	**0.02**
Input bias	-0.03	0.05	-0.13	0.08	-0.49	0.625
condition	**1.07**	**0.35**	**0.39**	**1.76**	**3.08**	**0.002**
Input bias x condition	0.04	0.08	-0.12	0.19	0.49	0.627

Table 12b: Mixed effects model for TD children

Parameter	Coefficient	SE	CI_low	CI_high	z	p
(Intercept)	-4.67	2.4	-9.38	0.04	-1.94	0.052
MLU	**2.12**	**0.78**	**0.59**	**3.64**	**2.72**	**0.007**
Input bias	-0.01	0.05	-0.11	0.08	-0.3	0.765
condition	**2.29**	**0.46**	**1.38**	**3.19**	**4.97**	**< 0.001**
Input bias x condition	0.13	0.1	-0.07	0.33	1.23	0.218

As shown in Tables 12a and 12b, consistent with the prediction of the Dual-Factor Model, children in both groups produced a higher proportion of correct forms (i.e., fewer OI errors) in the non-modal than modal condition; *M*=0.74 (*SD*=0.44) vs *M* =0.67 (*SD* =0.47) for the DLD group, *M* =0.94 (*SD* =0.24) vs *M* =0.81 (*SD* =0.39) for the TD group.

Analysis of avoidance effects

In order to investigate the issue of avoidance further, we plotted the proportion of valid responses (Correct forms + OI errors) as a function of group (DLD/TD) condition (modal/non-modal) and the chi-square input-bias predictor. As already noted, the finding of a high correlation between the input-bias predictor and the proportion of valid responses means that the findings observed with regard to this predictor may be unreliable, and this is equally the case for the modal and non-modal conditions.

On the other hand, visual inspection of the plot clearly indicates that the pattern of valid responses is similar for (a) the modal versus non-modal conditions and (b) the DLD vs TD groups. Thus, the findings reported above with regard to these predictors need not be disregarded entirely. To recap, (1) As predicted by the Dual-Factor Model, collapsing across group (DLD/TD), children produced a higher proportion of correct forms (i.e., fewer OI errors) in non-modal than modal contexts. (2) Also Consistent with the Dual-Factor

Model (though bearing in mind the caveat raised above regarding the interpretation of null effects), no effect of group (DLD vs TD) was observed for either condition. That said, while the apparent consistency of missing data across groups and conditions means that these findings should not be disregarded outright, they should still be treated as tentative, given the observed patterning of missing data with respect to the input-bias predictor. Perhaps, for example, the finding of fewer OI errors in non-modal than modal contexts would have been wiped out had children produced more valid attempts with verbs with which they struggle (e.g., *geben, heben, spielen*), and which therefore may have yielded a high rate of OI errors in both conditions. It is also important to note that the absolute rates of missing data (over 75% for some of the most problematic verbs) are far higher than in any comparable studies of which we are aware, which again underlines the need for caution when interpreting the present findings.

Finally, it is important to consider whether the observed pattern of (apparent) avoidance in and of itself tells us anything about German-speaking children's acquisition of inflectional morphology. The pattern is that, in general, verbs that are heavily biased towards appearing in finite (3sg -*t*) form (e.g., *geben, kriegen*, *schmecken*) tend to be avoided in both the modal and non-modal conditions. One interpretation of this pattern is that, counter to the prevailing claim in the literature, German children actually struggle with V2, and have difficulty learning how to inflect verbs that, because they tend to occur in finite form, appear predominantly in this position. Although no predictions were made regarding avoidance responses, this possibility is highly consistent with the general assumptions of the Dual-Factor Model and the computational model MOSAIC. If, as assumed by these models, children are learning from the right edge of the utterance – i.e. they have a strong recency bias – we would expect them to be more confident with verbs that tend to appear utterance finally (i.e., those that are more frequent in non-finite form) than with those that tend to appear in the V2 position (i.e., those that are more frequent in 3sg *-t* form). At the same time, the Dual-Factor Model and MOSAIC would struggle to explain why children show few avoidance errors for these predominantly non-finite verbs even in the finite (non-modal) condition of the present study (recall that avoidance responses pattern almost identically across the modal and non-modal conditions).

6.4 Discussion

The aim of this study was to use experimental data from German children with DLD and MLU-matched TD controls to compare two different models of the verb-marking deficit in DLD: the Extended Optional Infinitive hypothesis and the Dual-Factor Model. The study comprised a verb elicitation experiment designed to elicit German *3sg* (*-t*) verb forms in simple-finite contexts (e.g., *Lisa malt,* 'Lisa paints'…) and non-finite (*-en*) verb forms in compound-finite contexts (e.g., *Lisa kann malen,* 'Lisa can paint').

In fact, neither the EOI nor the Dual-Factor Model received clear support. With respect to the EOI hypothesis, the present study did not provide evidence for the prediction that the DLD group will produce more OI errors than the TD group across conditions (modal/non-modal). However, given that the sample size was relatively small, these results cannot be taken as evidence against the EOI hypothesis, particularly in the absence of an a-priori power analysis. For the same reason, this null result cannot be taken as support for the Dual-Factor Model which predicts similar rates of OI errors across the DLD and TD groups.

A potentially interesting finding is the effect of condition, such that, as predicted by the Dual-Factor Model, collapsing across group (DLD/TD), children produced more OI errors in modal (compound-finite) than in non-modal contexts. This finding is consistent with the assumption that, for German children, OI errors are learned from compound finite structures via modal deletion. Whereas in English, OI errors are learned from truncation of modals but can also reflect defaulting, which can give you a high rate of OI errors in the non-modal condition. However, in German the rate of OI errors is higher in the modal condition, because defaulting in German would not result in OI errors, but in agreement errors (see also chapter 5.3). It is less easy to explain under the EOI hypothesis, because this account sees OI errors as a result of a biologically based deficit in the child's underlying grammar. Nevertheless, this apparent support for the Dual-Factor over the EOI model must be considered tentative given both the concerns raised above over missing data, and the relatively small difference observed: 26% vs 17% OI errors. Indeed, one could argue that the Dual-Factor Model predicts an error rate of close to zero in simple-finite contexts, as opposed to the observed error rate of 17%. This higher error rate would have to be explained by some additional factor, such as the generalization of OI errors from modal to non-modal (simple finite) contexts.

Neither did the present findings yield support for the prediction of the Dual-Factor Model of an input effect: i.e., a correlation (for both the DLD and

TD groups) between children's tendency to produce OI errors with particular verbs in non-modal contexts and the relative frequency with which these verbs occur as non-finite versus finite forms in German child-directed speech. (though, as noted above it is important not to take the absence of a significant effect as strong positive evidence for a null effect). Nevertheless, this failure to observe an input effect stands in contrast to the findings of previous studies of the OI phenomenon in English (Räsänen et al., 2014; Kueser et al., 2018) on relative frequency.

One possible explanation is the finding that many children in both the DLD and TD groups generally avoided producing exactly those verbs that are predicted to show low rates of OI error in non-modal contexts: verbs that are heavily biased towards appearing in finite (3sg -*t*) form (e.g., *geben, kriegen*, *schmecken*). Indeed, previous studies of both children with DLD (e.g., Bishop et al., 2017) and 1- to 2-year-old TD children (Bender, Wieloch, Blanck and Siegmüller, 2012) have found that children avoid and/or struggle with verbs that tend to appear in finite form in V2 position. Indeed, the majority of children in the present study – in the DLD and TD groups alike – showed low rates of performance in the verb-comprehension and verb-production subtests of the the PDSS (Kauschke & Siegmüller, 2009). Moreover, at under 30 months, many of the children in the TD group were also considerably younger than those tested in previous studies.

Another possible explanation for the avoidance behavior observed can be found in the methodology of the elicitation experiment itself. Many of the answers given by the children were pragmatically appropriate in context (e.g. "Lisa buys an apple. Peter…", "an orange"). Although a similar method was used in the English study by Räsänen et al (2014), our impression is that this kind of ellipsis is considerably more natural in German than English (in which it sounds rather formal). Future studies should therefore attempt to take into account such language-specific considerations.

Finally, while the pattern of avoidance observed in the present study severely hampered our ability to test the predictions we set out to test, it is a potentially interesting finding in its own right. A prevailing view in the literature is that children learning German (and other V2 languages) master V2 word order very quickly. For example, under the hypothesis of Very Early Parameter Setting, Wexler (1998: 25) argues that "Basic parameters [including V2] are set correctly at the earliest observable stages, that is, at least from the time that the child enters the two-word stage at around 18 months of age". The pattern of avoidance observed in the present study points to a very different possibility: Due to limited short-term memory capacity, German-speaking children learn utterances from the right-hand edge, meaning that they rapidly master verbs that appear predominantly in utterance-final position (i.e., in compound-finite form), and struggle with verbs that appear predominantly in V2 position (i.e., in simple-finite form). Interestingly, this is exactly what would be predicted by a model such as MOSAIC.

That said, it is important to acknowledge that there are other possible factors that could lead to a higher rate of avoidance for verbs that appear predominantly in simple-finite form. For example, such verbs have a tendency to describe states rather than events, and so could be more difficult to illustrate in pictures in the context of an experiment. More broadly speaking, there is little consensus in the field about how to treat avoidance responses. On the one hand, when the theories under investigation primarily make predictions about the different forms that children will produce (here, finite versus non-finite), it clearly makes sense to exclude trials on which children produce neither. On the other hand, when trials are not missing at random, but seem to reflect some kind of avoidance of more difficult items, simply excluding such trials throws away potentially valuable information. Given that this question has no easy answers, we offer instead two simple suggestions. First, researchers should always be sure to analyze missing/unscorable responses for apparent patterns of avoidance. We know from our own experience that, in the rush to analyze the scorable responses, this important step is often neglected. Second, researchers should undertake extensive piloting designed to minimize the number of unscorable responses (for example, removing verbs that children do not seem to know, or that prove difficult to clearly illustrate in pictures).

To sum up, in the present study, a verb elicitation experiment was conducted in an attempt to compare the predictions of two theoretical approaches. The findings provided no support for the prediction of the EOI hypothesis that children with DLD would produce higher rates of OI errors than TD children, or (in contrast to previous studies of English) for the prediction of the Dual-Factor Model of a by-verb input-bias effect. The findings did provide some tentative support for the prediction of the Dual-Factor Model of higher rates of OI errors in the modal than non-modal condition. However, these conclusions must be considered tentative given that rates of avoidance were both high in general and correlated with the input-bias predictor (i.e., higher for verbs that appear predominantly in simple-finite form in the input). That said, the pattern of avoidance errors is consistent with the claim of the Dual-Factor Model that young children are subject to a recency effect, learning utterances from the right hand edge. Future studies of both German and other OI languages should take into account both the theoretical and methodological considerations raised by the present study, in order to shed greater light on the key phenomena of verb-marking error and the verb-marking deficit in DLD.

CHAPTER 7: Discussion

7.1 Summary of the findings

7.1.1 Summary of Study 1

The first study of this thesis (Chapter 4) consists of a verb elicitation experiment with English-speaking children with DLD and language-matched typically developing (TD) controls. In this study we tested two different models of the pattern of verb-marking error in simple-finite (e.g., *Lisa paints a flower*) and compound-finite contexts (e.g., *Lisa can paint a flower*). The Extended Optional Infinitive Hypothesis (Rice et al., 1995) predicts that children with DLD will perform worse than language-marched controls across both conditions. The Dual-Factor Model (Freudenthal et al., 2015a) predicts that children with DLD will produce more OI errors than the TD group in only the simple-finite condition, in which both groups (DLD and TD) will show sensitivity to the relative input frequency of the relevant verb in bare vs 3sg *-s* form (e.g., *paint* vs *paints*).

Neither of these models was supported in its entirety: No support was found for the prediction of the EOI hypothesis. The prediction of the Dual-Factor Model that DLD children would perform worse than language-matched controls in the simple-finite condition was supported. However, unlike two previous studies (Räsänen et al., 2014; Kueser et al., 2018), no input effect was found for TD children. Both studies found an input effect for TD children with a similar experiment with two conditions (Räsänen et al., 2014), and for both groups of children (Kueser et al., 2018). In our experiment this input effect could also be found but was mostly driven by children from the DLD group.

This finding supports the idea that DLD is characterized by an over-reliance on rote-learned input strings.

7.1.2 Summary of Study 2

The second study was a corpus-based investigation of children's use of finite and non-finite forms in spontaneous speech in German (Chapter 5). This analysis contrasted the prediction of the EOI hypothesis that children with DLD will produce higher rates of OI errors but are aware of position and agreement with the prediction of the Dual-Factor Model of higher rates of OI errors for children with DLD than TD children, but also agreement errors and positioning errors through defaulting. This study compared two large German corpora, one of a child with DLD (Bastian) and one of a language matched control (Leo), and revealed a developmental stage from MLU 1.71 to 2.24 in which Bastian produces OI errors at significantly higher rates than Leo at equivalent MLUs. This result is consistent with Rice et al.'s (1997) findings, and with the predictions of both the EOI and Dual-Factor Models.

The analysis of the verb-positioning errors and subject-verb agreement errors revealed that the child with DLD produces these errors at much higher rates than the EOI hypothesis predicts. This suggests that Bastian (DLD) is less sensitive to German word order than Leo (TD), and that at least some of the differences in rates of OIs can be explained by the tendency to use non-finite forms in the wrong position (i.e., V2). Furthermore, it supports the assumption of the Dual-Factor Model that children tend to default to high-frequency non-finite forms in simple-finite contexts, with DLD children being more likely to show this defaulting behaviour than typically developing children. We also observed a relationship between the by-verb rate of OI errors in

Bastian's and Leo's speech and the by-verb rate of infinitive versus finite forms in the input from their mothers. This finding was not predicted by the EOI hypothesis and is consistent with the assumption of the Dual-Factor Model that children learn OI forms from the input.

7.1.3 Summary of Study 3

Chapter 6 extended the findings of Chapter 5 by using an elicitation paradigm to look for verb-specific patterns of OI errors in child German. The study involved eliciting a range of verbs in two different conditions (a simple-finite 3sg *-t* condition (e.g., *Lisa **malt** ein Blume*, 'Lisa paints a flower') and a compound-finite *-en* condition (e.g., *Lisa kann eine Blume **malen***, 'Lisa can paint a flower'). These verbs differed in the relative frequency with which they occurred in finite and non-finite form in child-directed speech in the German TD corpus.

This study was also designed to allowed for investigation of the prediction of the Dual-Factor Model that children will produce more OI errors in compound-finite than simple-finite contexts, but also produce OI errors in simple-finite contexts at rates correlated with the relative frequency of the two forms of the particular verb in the input. We also set out to test the prediction of the EOI account that children with DLD will make more OI errors than language-matched controls.

In fact, we were not able to conduct a strong test of these predictions, since children from both the DLD and TD groups showed high rates of avoidance error, especially for those verbs that were biased towards finite forms in the input. Although the input bias effect predicted by the Dual-Factor Model for the simple-finite condition was not observed, this finding was not taken as evidence for the EOI hypothesis, given both the problematic patterns of avoidance error and children's observed sensitivity to the probabilistic distributional patterns in the input language in the corpus analysis in Chapter 5.

At the same time, however, as predicted by the Dual-Factor Model, both children with DLD and MLU-matched TD controls produced higher rates of OI errors in the compound-finite than the simple-finite condition. This finding constitutes some support (although, given the methodological problems raised above, only tentative support) for the claim of the Dual-Factor Model that OI errors are learned from compound finite structures in the input.

7.2 Overall implications of the findings

In the following sections we discuss the general implications of our findings and relate them to the previous literature. First, we consider previous claims that (a) verb semantics and (b) input frequency have an impact on children's production of finite versus non-finite forms. Second, we consider whether the EOI or Dual-Factor Model better explains the patterning of OI errors amongst children with DLD. Third, we consider the crosslinguistic evidence for theoretical accounts of OI errors by comparing the data for two languages under investigation, English and German. Finally, we discuss the implications of the present findings for the debate surrounding OI errors, focussing in particular on the question of an EOI stage.

7.2.1 The impact of verb semantics

Several previous studies from both the generativist and constructivist traditions have reported an influence of the semantic properties of verbs on rates of OI errors. These studies provide evidence that OI errors and correct finite forms tend to occur in complementary distribution in modal (compound-finite) and non-modal (simple-finite) contexts and with semantically different sets of verbs. Specifically, verbs that tend to appear mainly in modal contexts and to attract high rates of OI error tend to describe events (e.g., *build, cook, cut, wash*), rather than states (e.g., *be, have, need*). These semantic conditioning effects have been reported in a number of OI languages, including Dutch (Jordens, 1990; Wijnen, 1998); French (Ferdinand, 1996); Swedish (Josefsson, 2002), and, most importantly in the current context, German (Ingram & Thompson, 1996).

This claim is further sustained by Jordens (2012) and explained in his theory of the *Functional category system*, where he describes the syntactical development of children in different stages. At the lexical stage Jordens differentiates between state verbs that appear as finite forms and agentive verbs that appear more often as non-finite forms in children's speech, before they reach a functional stage in which they show the systematic use of topicalization and start to reorganize their grammar.

In a study with Dutch-speaking children, the authors confirmed that early in the OI stage, finite and non-finite verbs constitute of non-overlapping sets, in spite of multiple occurrences of a given verb type, even if this verb type is used frequently by the child (Blom & Wijnen, 2013). The absence of overlap in the early OI stage indicates that finite verb forms are initially unanalysed and, consequently, that the morphological marking of finiteness is not yet productive. In parallel with the increasing overlap, the authors describe a growth of lexical variation of finite forms.

The results from our studies support these claims in several ways. In our analysis of child directed speech from two German language corpora (Chapter 5) we found that both the child with DLD and the TD language matched control child tended to produce stative verbs more often as finites and eventive verbs more often as OI errors. For both children, a significant correlation was found between the rate at which they produced OI errors with particular verbs and the relative frequency with which those verbs occurred as non-finite versus finite forms in their input. This finding suggests that the semantic conditioning of OI errors in children's speech reflects the way in which semantically different sets of verbs pattern in the child's input. These findings are broadly consistent with the Dual-Factor Model and other input-driven accounts of the pattern of verb-marking error in children with DLD (e.g. Jordens, 2012; Leonard et al., 2015) but are not predicted by the EOI hypothesis which assumes that OI errors and correct forms appear in free variation.

A finding from our German elicitation study (Chapter 6) supports this claim further. The experiment had two different conditions, following the constructivist assumption that children learn forms from the input. German children from both the TD and DLD groups produced more OI errors in the modal (compound-finite) than the non-modal (simple finite) condition. This supports the assumption of the Dual-Factor Model that many OI errors occur as a result of modal drop (i.e., truncating compound finites), which offers an explanation of why rates of OI error tend to be higher for verbs that appear predominantly in modal contexts (i.e., eventive, rather than stative verbs).

The English verb elicitation experiment (Chapter 4) also included modal and non-modal conditions. In contrast to the German study, however, children produced more OI errors in the nonmodal (simple-finite) than the modal (compound-finite) condition. This suggests that, for English, defaulting to the highest frequency form may be a more important source of OI errors than modal drop/truncating of compound finites.

7.2.2 The impact of input frequency

One important question addressed by the current thesis is the constructivist claim that children's knowledge of verb inflection is acquired on the basis of the input language and can be directly related to different forms children hear. Generativist accounts do not assume such a relation between input and output forms and therefore predict no such input effect. They claim, instead, that the inflectional system develops through parameter setting and maturational processes (e.g., Wexler, 1998).

Previous studies of input frequency were able to show a by verb input effect. Kueser et al. (2018) replicated a study by Räsänen, et al. (2014), which shows that English children tend to produce bare forms in 3sg elicitation contexts when these verbs are biased in terms of their relative frequency in bare versus 3sg forms in English child-directed speech. The Kueser et al. (2018) study found the same effect for DLD children and a group of language-matched TD controls (with the children with DLD also producing significantly more bare forms in 3sg contexts than the typically developing children).

In our first study on English children (Chapter 4) this prediction was also supported. But, surprisingly, further analysis revealed that this effect was mostly driven by the children with DLD. Our interpretation of this result is that DLD children are more sensitive to the relative input frequency of the verb in 3sg -*s* vs bare form (Leonard & Deevy, 2011; Leonard et al., 2015; Kueser et al., 2018) because they show over-reliance on rote-learned input strings and under-appreciation of their wider linguistic and communicative contexts. Furthermore, this finding suggests noteworthy implications for therapy for children with DLD. As suggested in Chapter 4, there are intervention methods that argue for the influence of input frequency in therapy with DLD children. The child's input should be modified in such a way that the structures that need to be acquired occur with high frequency (Hadley, Rispoli, Fitzgerald & Bahnsen, 2011; Hadley, Rispoli & Holt, 2017; Leonard, 2014; McLean & Woods Cripe 1997, Paul 2007). The effectiveness of this method has already been proven for lexical (Siegmüller, Schröders, Sandhop, Otto & Herzog-Meinicke, 2010) and grammatical structures in German (Neumann, Baumann & Siegmüller, 2013).

In comparison to these English findings, the German elicitation experiment failed to show a significant input effect. This null finding could be partially explained by the high number of unscorable responses from both groups, particularly for verbs with an input bias towards the finite form.

In contrast to these findings, our German naturalistic data study of two children provided strong support for the influence of input. We looked at the relationship between the rate at which the two children produced particular verbs as OI errors and the rate at which those verbs occurred as infinitives versus finite forms in their input. For both children (one with DLD, one TD) we observed a significant positive correlation between the two variables.

To conclude, this demonstration across languages of a relationship between children's OI errors and their input language in terms of item-specific distribution constitutes strong support for the constructivist claim of the importance of the input and against the claim of the EOI hypothesis that language develops mainly through maturational and parameter-setting processes.

7.2.3 Accounting for the patterning of OI errors in children with DLD

In this section we consider whether the EOI or Dual-Factor Model better explains the patterning of OI errors amongst children with DLD. The panel of experts that coined the term DLD (to replace SLI; Bishop et al. (2016, 2017) noted that, while multiple domains of language can be affected (e.g., phonology, syntax, semantics, discourse, memory and pragmatics) many previous studies focussed mainly on the morpho-syntactic level. This is because most previous studies are of English which, due to its impoverished morphology, makes deficits at the morpho-syntactic level easy to identify.

Rice et al. (1995) and Rice & Wexler (1996) describe for English children with DLD an Extended OI stage. They found that these children produced higher rates of OI errors than language-matched controls in naturalistic data. They argued that the continued production of these errors reflects an underlying difference between the child and adult grammar that extends further up the age and MLU range for children with DLD than for TD children.

In our first study (Chapter 4) we tested the predictions of the EOI hypothesis and compared them to the predictions of the Dual-Factor Model, which predicts higher rates of OI errors for English children with DLD, but only in the simple-finite condition. This prediction of the Dual-Factor Model was confirmed by the results of our verb elicitation experiment on English, and is very difficult to account for under an EOI account, which includes no mechanism that would yield a difference between simple- and compound-finite conditions. An unexpected result of this study was that the DLD group seemed more sensitive to the input bias than TD group. This finding was not predicted, but is consistent with claims in the literature that DLD children show an over-reliance on rote-learned input strings and under-appreciation of their wider linguistic and communicative context (Leonard & Deevy, 2011; Leonard et al., 2015; Kueser et al., 2018). Again, this finding is very difficult to account for under an EOI account, which sees DLD simply as an extended Optional Infinitive stage, and includes no mechanism that explains either by-verb differences in general, or why they should be especially pronounced in DLD.

For German children with DLD, Rice et al. (1997) described higher rates of OI errors compared to language-matched TD controls. Furthermore, they claim that both groups made very few agreement or verb-positioning errors, because they produce finite verbs in second position and non-finite verbs in utterance-final position. However, these findings are challenged by other studies of German-speaking children with DLD. For example, Dannenbauer and Kotten-Sederqvist (1990) and Hamann, Penner & Lindner (1998) describe German-speaking children with DLD who produce non-finite forms in second position and finite forms in utterance-final position. Furthermore, Clahsen et al.

(1997) describe both verb-positioning and agreement errors, and Rothweiler et al. (2012) confirm problems with the production of correctly agreeing verb forms in German children with DLD.

These findings are consistent with the predictions of the Dual-Factor Model, that children with DLD (and to a lesser extent typically developing children) will sometimes default to the most frequent form of the verb in the input and hence produce subject-verb agreement errors (e.g., when the target form is significantly less frequent than a competitor) and also verb positioning errors (when children default to a more frequent non-finite form in a context that requires a finite form).

In our naturalistic data study (Chapter 5) we analysed the German child with DLD not only for rates of OI errors, but also for positioning errors and subject-verb-agreement errors. We found that Bastian made significantly more positioning errors than his language-matched control, and also produced a relatively large number of subject-verb agreement errors. These results count directly against the predictions of the EOI account that German-speaking children with DLD will not make positioning or agreement errors, and in favour of the predictions of the Dual-Factor Model; specifically, the defaulting factor.

The results from the verb elicitation experiment with German children with DLD and language matched TD controls (Chapter 6) also provides some support for these claims (though, as noted above, the picture is complicated by the high and non-random rates of missing responses). No support could be found for the prediction of the EOI account of higher rates of OI errors in the DLD than the TD group. In contrast, the Dual-Factor Model predicts no such difference, because the groups have been matched for MLU.

To sum up, our investigations of children with DLD yielded four important findings. First, the English children with DLD showed higher rates of OI errors in the simple- than compound-finite condition, which was predicted by the Dual-Factor Model, but not the EOI account. Second, these children seem to be more sensitive to the input bias implemented in the experiment than TD children; a finding for which the EOI account offers no ready explanation. Third, the German child with DLD investigated in our naturalistic data also showed a significant positive correlation between the rate at which he produced particular verbs as OI errors and the rate at which those verbs occurred as infinitives versus finite forms in the input. This again supports input-driven accounts, including the Dual-Factor Model, but is difficult to explain under an OI account. Finally, the naturalistic-data analysis of verb positioning errors and verb agreement errors also provided support for the Dual-Factor Model against the EOI account, which predicts that such errors should not occur. These errors should not be taken as evidence against the child’s diagnosis of DLD, since other studies (Dannenbauer & Kotten-Sederqvist, 1990; Hamann et al., 1998; Clahsen et al., 1997; Rothweiler et al., 2012) argue for positioning errors and verb agreement errors as further clinical markers for DLD. On the contrary, since the reported findings count against the EOI hypothesis, an EOI stage should not – in and of itself – be seen as a defining characteristic of DLD in German.

7.2.4 The OI pattern cross-linguistically

In this section we consider the crosslinguistic evidence for theoretical accounts of OI errors by comparing the data for two languages under investigation, English and German. The great strength of the EOI hypothesis is that it provides an integrated cross-linguistic account of the pattern of verb-marking error in both typically developing children and children with DLD. Thus, it can potentially explain why children learning obligatory subject languages such as Dutch, English, French and German make OI errors at substantially higher rates than children learning INFL-licensed null subject languages such as Italian and Spanish (Wexler, 1998). It can also explain why other kinds of verb-marking errors are rare in both types of language (Harris & Wexler, 1996; Hoekstra & Hyams, 1998). However, it is important to recognise that the EOI Hypothesis assumes that the rate at which OI errors occur is determined by a single underlying difference between the child and the adult grammar. Therefore, the EOI hypothesis predicts a relatively undifferentiated pattern of OI errors, in which such errors occur across different finite contexts and across different verbs.

In contrast to these assumptions, the MOSAIC model – later combined with a defaulting mechanism to yield the Dual-factor account – assumes that OI errors are learned from compound-finite structures in the input and has been shown to explain the cross-linguistic patterning of errors across Dutch, English, German and Spanish (Freudenthal, et al., 2006; Freudenthal, et al., 2007). The Dual-Factor Model predicts higher rates of OI errors for children learning English, as compared to other languages like German and Dutch, and why these errors persist even when their utterances become longer and more complex (by which time such errors have mainly disappeared in other languages). The difference can be explained, under the Dual-Factor Model, by the process of defaulting. Children learning all languages show a tendency to default to high frequency forms of the relevant verb, but only for English does this process yield (apparent) OI errors, due to the preponderance of “bare” forms in the input.

For German, the reason why the DLD group produced higher rates of OI errors that the TD group, is different than for English. Our German study (Chapter 6) showed a strong effect of condition, which supports the idea that OI errors are truncated modals. German children produce OI errors at an early stage in development, and DLD children produce them for longer, because they are slow learners. But when the MLU of German children increases, OI errors disappear; a finding confirmed by the corpus analysis of a child with DLD reported in Chapter 5. We could not find evidence, in this German naturalistic data study, for an MLU-matching effect, which was found in Rice et al.’s study (1995) of English children with and without DLD.

The crosslinguistic similarities and differences we found across English and German with respect to the patterning of OI errors are better explained by the Dual-Factor Model than the EOI account. The similarities are due to the fact that the first of the two factors posited – truncating compound-finite (here, modal) structures – operates in the same way across the two languages, yielding OI errors in both. The differences are due to the fact that the second of the two factors posited – defaulting – yields OI errors in English but verb-agreement errors in German (as observed in the present naturalistic data study). Consequently, while – descriptively speaking – there indeed appears to be an EOI stage in English, the present findings suggest that it is in fact an extended defaulting stage. For German there is less evidence that an EOI stage (even at a descriptive level) really exists. Even the evidence provided by Rice et al. (1997) seems to be limited, and – as set out above – is challenged by other naturalistic studies of German. This conclusion is supported further by the naturalistic results reported in Chapter 5, where the child with DLD produces higher rates of OI errors than his language-matched TD control only for a very short period.

7.2.5 The OI pattern in general

In this section, we discuss the implications of the present findings for the debate surrounding OI errors in general, though focussing in particular on the question of an EOI stage. The finding that TD children produce non-finite forms in finite contexts, before they acquire the correct pattern of finite verb marking is very well established, having been reported in numerous studies (e.g., Brown, 1973; Rizzi, 1993/1994, Hyams, 1996; Hoekstra & Hyams, 1998; Poeppel & Wexler, 1993, Wexler, 1994; 1998). Debate continues, however, as to the best theoretical explanation of this finding.

Adopting a nativist-generativist perspective, Wexler (1994, 1998) explains this phenomenon by arguing that, although children have correctly set all the inflectional and clause structure parameters of their language from a very early age, there is a developmental stage (the OI stage), during which they are subject to a Unique Checking Constraint (UCC). This constraint competes with other constraints in the child's grammar and results in the optional use of finite and non-finite forms in finite contexts. The studies of Rice et al. (1995) and Rice et al. (1997) also reported this phenomenon for English and German children with DLD. The authors claim that DLD children produce OIs for a protracted period of time, which they termed an extended OI (EOI) stage. This characterization of DLD was largely accepted for 30 years, even though other studies (Jordens, 2012; Leonard et al., 2015; Rothweiler et al.,

2012) have questioned the existence of an EOI stage for DLD children in several languages. One important argument made by Rice et al. (1995) is that children with DLD will still produce higher rates of OI errors compared to younger TD children matched on MLU.

In contrast to the predictions of the EOI hypothesis stands an input driven account. The Dual-Factor Model is able to predict language specific rates of OI errors by combiningg (1) a bias to learn from the right edge of the utterance (instantiated in the computational Model MOSAIC (Freudenthal, et al., 2006, 2010, Freudenthal, et al., 2007; Freudenthal, et al., 2015a; 2015b) and (2) an effect whereby children probabilistically default to the highest frequency form of a given verb in their input. Therefore, the Dual-Factor Model assumes that OI errors are learned from the input and disappear when children's utterances become longer and more complex.

A central aim of this thesis was to investigate, with different methods and across different languages, whether or not an EOI stage exists and, therefore, whether the EOI account or the Dual-Factor Model best explains the patterns of OI errors observed. A number of findings bear directly on this question.

First, our analysis of two German language corpora found that the by-verb rate of OI errors produced by the DLD and TD child was related to the semantic distribution of verbs in the input language (Chapter 5). In the German verb elicitation experiment this effect was also found, in the form of an effect of condition (Chapter 6). This pattern of semantic distribution is not predicted by the EOI hypothesis, which assumes that OI errors and correctly-inflected forms are in free variation, but is consistent with the claim of the Dual-Factor Model that OIs are learned from compound-finite structures in the input.

Second, the impact of the input on children's production of OI errors was further supported by the observed correlation between the rate at which these two children produced particular verbs as OI errors (vs correctly-inflected tensed forms) and the rate at which those verbs occurred as non-finite versus finite forms in child directed speech (Chapter 5). The same effect of input bias was found in our English verb elicitation experiment, with the DLD children found to be especially sensitive to the input distribution (Chapter 4). These findings – in both naturalistic and experimental contexts – are not predicted by the EOI hypothesis which assumes that the transition to finiteness marking depends on maturation (what Wexler, 1998, calls the "withering away" of the Unique Checking Constrain), rather than verb-by-verb learning.

Third, there nevertheless does seem to be some evidence for an (apparent) EOI stage in English, because children with DLD produced OI errors at higher rates than MLU-matched TD children. But this prediction is only true for our English verb elicitation experiment and only in the simple-finite condition (Chapter 4). The fact that, as predicted by the Dual-Factor Model, this finding was observed only in the simple-finite condition suggests that DLD reflects an extended stage of defaulting in non-modal contexts, rather than of optional finiteness marking per se. No evidence was found for the prediction of the EOI hypothesis, that the DLD group would produce higher rates of OI errors than the language matched TD control group across both conditions.

Indeed, when we look at our two studies of German (Chapter 5 and 6) the evidence for an EOI stage becomes weaker still. In the verb elicitation experiment, the rates of OI errors differed by condition (modal > nonmodal), but no effect of group (DLD vs TD) was found. Recall that the EOI account predicts just such an effect (i.e., that children with DLD will produce higher rates of OI errors than language-matched TD controls). The observed effect of condition is consistent with the predictions of the Dual-Factor Model and suggests further support for the assumption that in German (as in English) OI errors are learned from truncated compound constructions in the input.

Similar results were found in the German naturalistic data study (Chapter 5). Here, the Dual-Factor Model predicts that the rate of OI errors in both groups will be related to the mean length of utterance (MLU) that the child is able to produce, and that there will therefore be no difference in the rate of OI errors between the child with DLD and the TD child at equivalent MLUs. In fact, the child with DLD was found to produce higher rates of OI errors, which suggests some support for the EOI hypothesis. On the other hand, the results also showed that this period is much shorter than predicted by the generativist EOI account: The EOI stage is restricted to a very narrow MLU range and a very short period of time.

The results of this analysis also raised a methodological question: The TD child seems to produce more complex utterances than the DLD child, when they were matched on MLUw. Therefore, we matched both children on MLUv and compared their rates of OIs. On this analysis, the children become even more similar, which counts against an EOI stage for German children with DLD. Furthermore, the positioning errors and verb agreement errors found in our analysis (Chapter 5) are difficult to reconcile with an EOI account which claims that basic inflectional and word order properties have already been mastered, with DLD characterized solely by an extended OI stage. Both types of errors, however, are consisted with the Dual-Factor Model (particularly the defaulting factor).

To sum up, English and German children with DLD and language matched TD controls produce OI errors in both modal (compound-finite) and non-modal (simple-finite) contexts. But our analysis provides evidence, in numerous different ways, of the impact of the input on children's production of OI errors. We therefore conclude that, although neither account was supported in its entirety, the Dual-Factor Model offers a better account than the EOI account of the OI phenomenon.

7.3 Methodological considerations and suggestions for future research

In this thesis we used two different methods to investigate verb-marking errors in children with DLD and language-matched controls in English and German. Using a verb elicitation experiment conducted in English and German and the analysis of naturalistic data from two German corpora, we tested two different models of the pattern of Optional Infinitive (OI) errors: The Extended Optional Infinitive (EOI) hypothesis and the Dual-Factor Model.

The goal of the English verb elicitation experiment reported in Chapter 4 was to replicate and extend findings from previous studies (Räsänen et al., 2014; Kueser et al., 2018), with children with DLD and language-matched TD controls. A further goal was to expand these findings to German with the study reported in Chapter 6. Although previous studies using this method seemed to be very successful, and the findings clear, we could not find the same strong effects in both languages. Therefore, although this method clearly has some advantages, it is also important to consider its limitations, particularly those specific to the present studies.

As described in the Method sections in both studies (Chapters 4 and 6) we see relatively high drop-out rates for children who took part in the experiments, particularly the German study: Many children avoided particular responses and many answers had to be coded as unscorable.

When children struggle to complete an elicited production task, it cannot be assumed that they do not have the required linguistic knowledge. Children may struggle because they do not understand the task. Thus, a child's failure to respond when 3sg verb forms are elicited may not be due to her lack of knowledge of 3sg verb forms, but her lack of understanding of the nature of the task.

One possible reason for the apparent failure of some children to understand the task could be the very young age of the participants in the experiments: Children aged between 25 months and 36 months are not very familiar with an experimental setting and/or with using a computer and can be very shy, when they are prompted to complete a sentence. Thus, although other studies have used this method successfully with children as young as 25 months (Olguin & Tomasello, 1993), such studies generally focus on simple nouns. It might be better for the investigation of the verb tense/agreement marking pattern to study children aged at least 30 months and older.

Another consideration is that the task should make communicative sense. In our experiment we introduced the task as a game on the laptop, where the children could push a star button to move to the next slide, when they completed the sentence and described what the child on the picture was doing. Although this task served to keep the children motivated, it did not necessarily create a scenario in which describing the picture made communicative sense. It might be better in future to frame the child's task as describing the picture to a second experimenter who cannot see the screen, possibly so that she can search for a matching bingo card to give to the child as part of a game (e.g., Rowland, Chang, Ambridge, Pine and Lieven (2012) used this stem completion technique in their priming study to ensure that the target sentence contained the target verb. The experimenter produced the prime sentence and the participant produced the target sentence. After each sentence, the second experimenter checked if she had the Bingo card corresponding to that sentence).

Another important consideration is language-specific factors of the experiment. Although an almost-identical method was used for English and German, German children showed considerably higher levels of avoidance of the target verbs, particularly those that are biased towards 3sg (vs non-finite) form in the input. One possible reason for this pattern could be that they have not yet acquired sufficient lexical knowledge of these verbs, which makes sense under the assumption of the Dual-Factor Model that children learn from the right edge of the utterance, and so struggle to learn verbs that appear mainly in the V2 position. Regarding the higher general levels of avoidance responses in German, as we noted in Chapter 6, it is common in enumerations (e.g. "Lisa gets a muffin. Peter…", "a lollipop") not to produce the verb again. If the children see the introductory sentence as the beginning of an enumeration, it would be correct to complete the sentence by producing the second object only. Furthermore, some children quite often used higher frequency synonyms when low-frequency verbs were the target. Instead of the target verb, children often produced so-called GAP verbs (*do, make, get*). This was especially the case for German children with DLD (Chapter 6) and, indeed, has been described as a symptom of DLD in the literature (Bishop et al., 2017).

For any experiment investigating morphology it is important to consider whether to use real, familiar items (usually verbs or nouns) or novel items. Novel verbs provide information, regarding whether or not children have productive knowledge. With familiar verbs, children can produce particular lexical items that may have been rote-learned (e.g., *builds*), and thus are not necessarily indicative of productivity. For our research questions, it was important to employ real verbs in the studies in order to investigate graded frequency effects on children's production. The biggest advantage of the experimental production methods used in Chapters 4 and 6 is that the experimenter has much greater control over the target items (here verbs) and structures (here, simple- versus compound-finite structures), than with naturalistic data. That said, an elicited imitation paradigm might have been more successful in persuading children – particularly the German children – to attempt to use the target verbs.

In contrast, the study reported in Chapter 5 used naturalistic data from two German corpora. Here the experimenter has no control as to whether the structures or items of interest will be produced by the child during the recording. Again, it must be acknowledged, that if a child does not produce the relevant structures, it cannot be concluded that the child is not able to produce them or lacks the relevant linguistic knowledge.

However, this problem was mitigated to some extent by the fact that both corpora are from large longitudinal studies, where the children were recorded over several years and a large amount of data was available for our analysis. Bastian was recorded weekly for 60- to 90-minutes from 1;8 to 7;4 years and Leo's speech was recorded and transcribed almost daily from the age of 1;11 to 3;11 years, and five times a month from the age of 4;00 to 4;11 years. Many recordings over a long period of time are the best way to ensure that the items and structures under investigation are produced (or at least attempted) by the children. Many previous studies (Clahsen, 1986; Poeppel & Wexler, 1993; Clahsen, Marcus, Bartke & Wiese, 1996; Bittner, 2003; Rice et al., 1997) have relied on the analysis of much thinner naturalistic speech samples, which can make it difficult to detect relatively small effects, such as the input-bias effect observed in the German corpora, as well as difference between rates of OI errors in modal versus non-modal contexts.

In all three studies, children with DLD were compared to younger typically developing children. In all cases, language-matching was done by Mean Length of Utterance (MLU). This method of matching is used in various studies (Kueser, et al., 2018; Leonard et al., 2015; Rice et al, 1997), but some researchers (Eisenberg, Fersko & Lundgren, 2001; Johnston, 2001; Johnston, Miller, Curtiss & Tallal, 1993; Oosthuizen & Southwood, 2009) argue that MLU matching should be used with caution. The calculation method must be clearly described and should be comprehensible if children from two different groups (here DLD and TD) are being compared. In our German naturalistic data study, we observed differences in the complexity of the utterances produced by the DLD and TD children, but these differences were not eliminating by MLU matching, instead requiring matching on MLUv. Especially for languages like German it does not seem to be the case that rates of OI errors are higher amongst children with DLD than TD children with similar MLUs. It is therefore necessary in future studies to consider other matching methods.

With regard to future studies, one interesting possibility is the pre-registration of studies before testing starts, which could include exclusion criteria (for example, excluding children with more than 25% missing data). The consequence would be to keep recruiting children, to obtain a sufficient quantity of data to achieve adequate statistical power. Of course, we could have excluded children post-hoc in the present study, but the difficulty here is that there is no non-arbitrary way to set the cut-off, meaning that very different patterns of results could result, with no way of determining which to choose. For the experiments, such a criterion would presumably have resulted, in practice, in the recruitment of older children (e.g. TD children older than 30 months).

Both of the present experimental studies focussed on 3sg (-s/-t) forms in the simple-finite condition, largely for practical reasons (many other forms are zero-marked particularly in English). However, it would be interesting to see for German, and other languages, whether children are producing OI errors and/or defaulting behaviour, for other person/number forms. For Polish and Finish a recent study on verb inflection (Engelmann, Granlund, Kolak, Zreder, Ambridge, Pine, Theakston, & Lieven, 2019). used a novel method involving photographs of heads (of the experimenter, the child and a third person) that are added in real time to animations. This method allows, for the first time, for the elicitation of forms such as 1sg and 1pl using video animations. A replication of the Engelmann et al. (2019) study with German children with DLD and TD language matched controls would help us to understand more about the process of the acquisition of inflection. Another interesting extension of the experiment could be the inclusion of children with a wide range of MLUs to investigate whether their tendency to default to the highest frequency form of the verb in the input decreases with increased MLU.

7.4 Concluding remarks

This thesis has investigated the acquisition of inflectional verb morphology by focusing on two different theoretical approaches that attempt to explain the phenomenon of Optional Infinitive errors.

The generativist EOI hypothesis predicts that children with DLD will produce these forms for longer and at higher rates than language-matched TD controls, regardless of context (modal/non-modal). None of the present findings provide support for this prediction. Children with DLD failed to show significantly higher rates of OI errors across both conditions in our experimental studies of both English and German. Although an apparent EOI stage could be observed for English children with DLD, on closer inspection, this appears to be an extended period of defaulting, rather than of OI errors per se. Neither was such a pattern observed in our analysis of a naturalistic dataset, which also revealed positioning and agreement errors, which are also not predicted by the EOI hypothesis.

Rather, the present findings point to an input-driven account: In the main, the Dual-Factor Model is able to explain the results of both the experiments (Chapter 4 and 6) and the naturalistic data (Chapter 5) cross-linguistically, particularly the observed verb-specific distribution in children's use of finite and non-finite forms. This pattern constitutes strong evidence for the argument that children's inflectional knowledge is acquired on the basis of the input. Cross-linguistic differences in the rates of OI errors are explained, under the Dual-Factor Model, by the process of defaulting to the highest frequency form of the verb in the input; a process that yields (apparent) OI errors in English, but verb agreement and/or positioning errors in German.

While this thesis has provided important evidence for this account, it has also demonstrated that more work is needed to improve the experimental designs used to test these and other hypotheses and to investigate both language-specific and language-general processes – as well as explain cross-linguistic differences – in children's acquisition of finiteness marking and of inflectional morphology in general.

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Appendices

Appendix A: Exclusion process for participants from Study 1

Participants tested overall in the UK				**102**
Participants assigned to		Participants excluded because of results in language tests	Participants excluded because no valid responses in experiment	**Final sample**
TD group	54	3	1	**50**
DLD group	48	23	0	**25**
				75

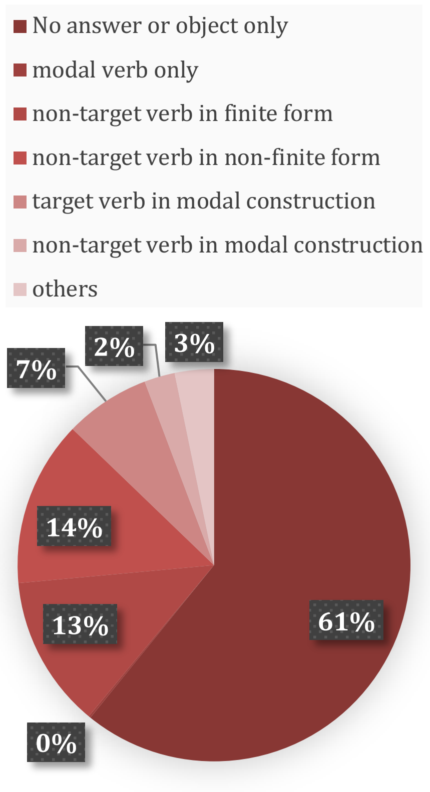
Appendix B: Relative frequency for verbs from the elicited production task taken from the Manchester corpus input

Verb	Relative frequency	Raw frequency	Raw frequency of 3sg -s forms	Raw frequency of non-finite forms	Raw frequency of other finite forms	Raw frequency of other non-finite forms	Chi square	Log	Chi_Dir_Log	Bias
bake	0.091	11	1	10	7612	119398	0.19	0.17	0.17170081	Finite
bring	0.045	553	25	528	7588	118880	2.14	1.14	-1.1435912	Non-finite
build	0.006	633	4	629	7609	118779	32.46	3.51	-3.5102908	Non-finite
buy	0.012	330	4	326	7609	119082	13.42	2.67	-2.6689564	Non-finite
carry	0.022	134	3	131	7610	119277	3.36	1.47	-1.4716455	Non-finite
catch	0.011	184	2	182	7611	119226	7.87	2.18	-2.1830533	Non-finite
chase	0.05	20	1	19	7612	119389	0.04	0.03	-0.0344424	Non-finite
chop	0.111	9	1	8	7612	119400	0.42	0.35	0.34951484	Finite
drink	0.106	161	17	144	7596	119264	5.96	1.94	1.94071317	Finite
drive	0.1	270	27	243	7586	119165	7.71	2.16	2.16432144	Finite
feel	0.093	161	15	146	7598	119262	3.16	1.43	1.42548615	Finite
fit	0.232	1135	124	1011	7489	118397	49.43	3.92	3.92068356	Finite
get	0.028	5343	152	5191	7461	114217	98.14	4.6	-4.5965651	Non-finite
give	0.02	1255	25	1230	7588	118178	36.02	3.61	-3.6114856	Non-finite
make	0.065	2657	173	2484	7440	116924	1.29	0.83	0.82873659	Finite

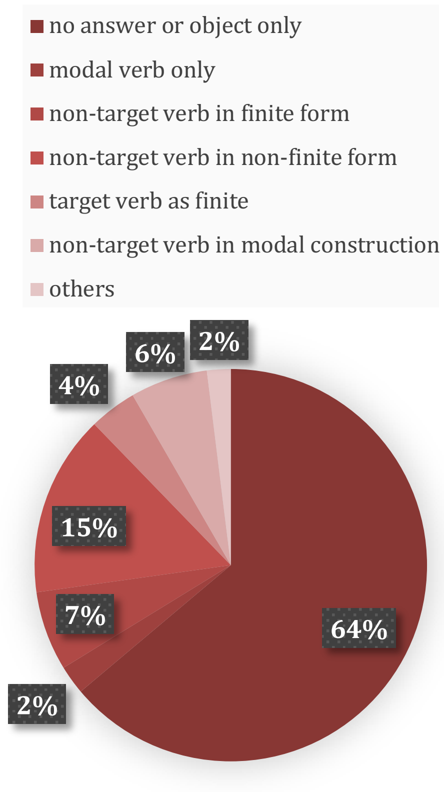
Verb	Relative frequency	Raw frequency	Raw frequency of 3sg -s forms	Raw frequency of non-finite forms	Raw frequency of other finite forms	Raw frequency of other non-finite forms	Chi square	Log	Chi_Dir_Log	Bias
paint	0.118	76	9	67	7604	119341	4.62	1.73	1.72576079	Finite
play	0.013	1419	18	1401	7595	118007	56.86	4.06	-4.0580707	Non-finite
pull	0.015	715	11	704	7602	118704	25.33	3.27	-3.2706792	Non-finite
ride	0.154	83	13	70	7600	119338	13.78	2.69	2.69338539	Finite
roll	0.048	125	6	119	7607	119289	0.32	0.27	-0.2748486	Non-finite
see	0.003	5311	17	5294	7596	114114	316.65	5.76	-5.7609403	Non-finite
shout	0.107	28	3	25	7610	119383	1.11	0.75	0.74562456	Finite
smell	0.265	34	9	25	7604	119383	25.31	3.27	3.26995211	Finite
stick	0.06	215	13	202	7600	119206	0	0	0.00107372	Finite
stroke	0	29	0	29	7613	119379	1.85	1.05	-1.0470916	Non-finite
taste	0.324	37	12	25	7601	119383	45.92	3.85	3.84839015	Finite
visit	0.056	18	1	17	7612	119391	0.01	0.01	-0.0061094	Non-finite
wash	0.02	205	4	201	7609	119207	5.95	1.94	-1.9394365	Non-finite
watch	0.009	323	3	320	7610	119088	14.74	2.76	-2.7563796	Non-finite
wear	0.111	267	19	248	7594	119160	0.6	0.47	0.46904743	Finite

Appendix C: Analysis of error rates in English verb elicitation experiment

a) In non-modal condition



b) In modal condition



Appendix D: Bastian's and Leo's rates of finites, OI's and compounds at matching MLU's

Matching MLU	MLUv		% finites		% OI's		% compounds	
	Bastian	Leo	Bastian	Leo	Bastian	Leo	Bastian	Leo
1.71	2.134	2.722	54.76	52.78	40.48	44.44	4.76	2.78
1.79	2.058	2.307	72.34	56.00	25.53	28.00	2.13	16.00
1.88	2.345	2.622	58.95	72.55	38.95	21.57	2.11	5.88
2.06	2.635	3.241	40.98	65.00	44.26	22.00	14.75	12.00
2.10	2.706	3.936	67.53	85.23	18.18	4.03	14.29	10.74
2.10	2.759	4.315	55.95	77.38	14.29	2.26	29.76	20.36
2.19	2.639	4.208	78.31	86.30	13.25	2.05	8.43	11.64
2.24	3.186	4.407	82.14	92.00	3.57	2.00	14.29	6.00

Appendix E: Exclusion process for participants from Study 3

Participants tested overall in Germany				**129**
Participants assigned to		Participants excluded because of results in language tests	Participants excluded because of lower MLU than 2.4 or higher MLU than 4	**Final sample**
TD group	64	7	25	**32**
DLD group	65	26	7	**32**
				64

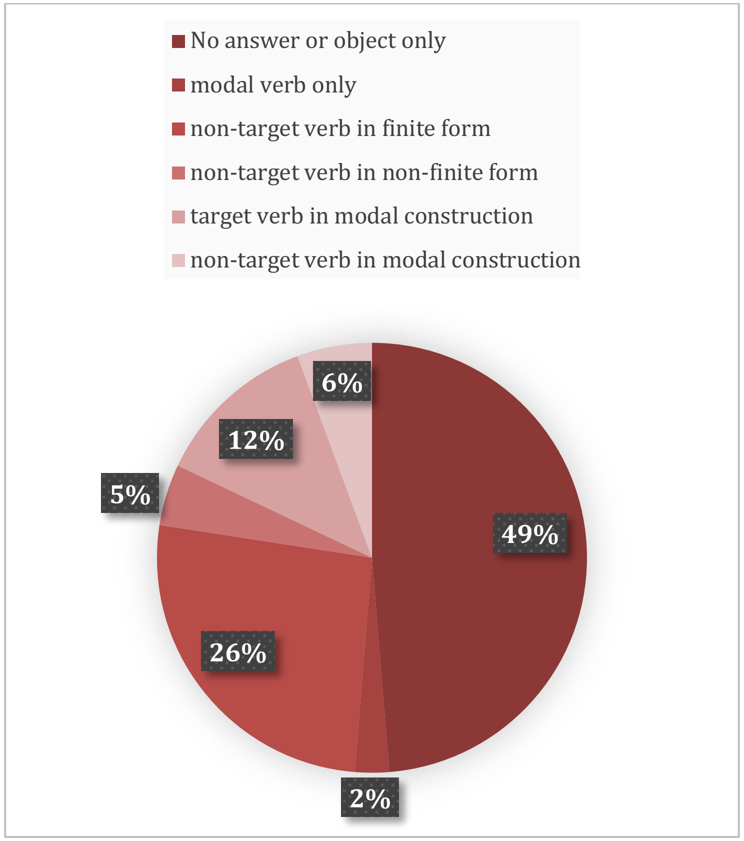
Appendix F: Relative frequency for verbs from the elicited production task taken from the Leo corpus input

Item German	Item English	Relative frequency	Raw frequency	Raw frequency of 3sg -s forms	Raw frequency of non-finite forms	Raw frequency of other finite forms	Raw frequency of other non-finite forms	Chi square	Log	Chi Dir Log	Bias
angeln	fish	0.145	88	17	71	56958	26861	95.41	4.57	-4.569	Non-finite
backen	bake	0.104	58	9	49	56966	26883	73.08	4.31	-4.305	Non-finite
baden	bath	0.140	55	8	47	56967	26885	71.89	4.29	-4.289	Non-finite
basteln	make	0.095	30	8	22	56967	26910	23.41	3.20	-3.195	Non-finite
bauen	build	0.055	460	112	348	56863	26584	402.59	6.00	-6.000	Non-finite
besuchen	visit	0.073	52	4	48	56971	26884	86.55	4.47	-4.472	Non-finite
bringen	bring	0.677	150	102	48	56873	26884	0.00	0.00	0.001	Finite
erschrecken	scare	0.800	30	22	8	56953	26924	0.41	0.34	0.341	Finite
fahren	drive	0.657	1199	692	507	56283	26425	57.93	4.08	-4.076	Non-finite
fühlen	feel	0.786	28	22	6	56953	26926	1.46	0.90	0.901	Finite
geben	give	0.875	781	690	91	56285	26841	151.20	5.03	5.025	Finite
gucken	watch	0.138	1079	236	843	56739	26089	1062.62	6.97	-6.969	Non-finite
heben	lift	0.786	25	18	7	56957	26925	0.19	0.18	0.176	Finite
kaufen	buy	0.179	81	18	63	56957	26869	77.63	4.36	-4.365	Non-finite
kleben	stick	0.377	95	32	63	56943	26869	51.09	3.95	-3.953	Non-finite
kriegen	get	0.749	678	510	168	56465	26764	16.80	2.88	2.879	Finite
malen	paint	0.118	577	167	410	56808	26522	404.62	6.01	-6.005	Non-finite
putzen	clean	0.200	59	11	48	56964	26884	65.73	4.20	-4.201	Non-finite

Item German	Item English	Relative frequency	Raw frequency	Raw frequency of 3sg -s forms	Raw frequency of non-finite forms	Raw frequency of other finite forms	Raw frequency of other non-finite forms	Chi square	Log	Chi Dir Log	Bias
riechen	smell	0.775	63	52	11	56923	26921	6.20	1.97	1.974	Finite
rufen	shout	0.818	40	31	9	56944	26923	1.69	0.99	0.990	Finite
schmecken	taste	0.937	211	180	31	56795	26901	29.40	3.41	3.415	Finite
schneiden	cut	0.132	85	30	55	56945	26877	41.51	3.75	-3.750	Non-finite
sehen	see	0.699	2017	1513	504	55462	26428	47.93	3.89	3.890	Finite
spielen	play	0.153	316	52	264	56923	26668	385.20	5.96	-5.956	Non-finite
streicheln	stroke	0.133	24	9	15	56966	26917	10.18	2.41	-2.414	Non-finite
tragen	carry	0.447	54	26	28	56949	26904	9.67	2.37	-2.368	Non-finite
trinken	drink	0.143	277	54	223	56921	26709	298.81	5.70	-5.703	Non-finite
waschen	wash	0.114	46	7	39	56968	26893	58.62	4.09	-4.088	Non-finite
würfeln	roll	0.056	97	23	74	56952	26858	87.01	4.48	-4.477	Non-finite
ziehen	pull	0.193	316	123	193	56852	26739	122.21	4.81	-4.814	Non-finite

Appendix G: Analysis of error rates in German verb elicitation experiment

a) In non-modal condition



b) In modal condition