German children's productivity with simple transitive and complement-clause constructions: Testing the effects of frequency and diversity*

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Abstract

The development of abstract schemas and productive rules in language is affected by both token and type frequencies. High token frequencies and surface similarities help to discover formal and functional commonalities between utterances and categorize them as instances of the same schema. High type frequencies and diversity help to develop slots in these schemas, which allow the production and comprehension of novel utterances. In the current study we looked at both token and type frequencies in two related constructions in German child-directed speech: simple transitive and complement-clause constructions. Both constructions contain high frequency verbs, which potentially support the development of verb-specific schemas. However, only the frequent verbs in the transitive constructions occur with a variety of subject types, which also supports the development of a slot in the subject position.

We then used an elicited production task to compare 4- and 5-year-old German-speaking children's productivity with simple transitive constructions and complement-clause constructions. The children were prompted to change the subjects of high and low frequency simple transitive verbs, such as essen *'eat' and* naschen *'nibble', mental-state complement-taking verbs, such as* denken *'think' and* vermuten *'presume', and communication complement-taking verbs, such as* sagen *'say' and* berichten *'report'. In accordance with earlier findings, children had less difficulty producing new utterances with high frequency transitive verbs than with low frequency transitive verbs. For the other verb classes, however, we found either reverse frequency effects or no frequency effects. For these verb classes, children's productivity can be determined by*

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diversity rather than simple token frequency. We discuss how token frequency interacts with diversity, discourse function, semantic complexity, and syntactic complexity.

Keywords: *Frequency; diversity; productivity; complement clause; transitive; discourse function.*

1. Introduction

In usage-based accounts, frequency is considered one of the main factors driving the acquisition of schemas and productive rules, but it is also acknowledged that frequency has different dimensions (especially types and tokens), and that it interacts with other factors, such as diversity and flexibility, discourse function, salience, complexity, etc. In the current study, the main focus is on the interaction between frequency, diversity and flexibility, and discourse function. We will look at children's development of schemas and productive rules for simple transitive and complement-clause constructions. Both constructions contain high and low frequency verbs. In our corpus study of German child-directed speech, we analyzed how flexibly various high and low frequency verbs are used in these constructions. In particular, we analyzed the level of diversity of subject types used together with various verbs. We will discuss how this diversity is related to the function of simple transitive and complement-clause constructions. We will then present an experimental study, where we tested children's ability to change the subject of various high and low frequency verbs in simple transitive and complement-clause constructions that display different levels of diversity.

1.1. *Development of productivity*

Language acquisition—and language comprehension and production in general—involves three main processes: segmentation, categorization, and recombination. Children have to divide their linguistic input into segments before they can be productive and recombine these segments to form novel utterances. It has been shown that young infants can readily segment linguistic and other auditory stimuli based on transitional probabilities and sound patterns (e.g. Aslin et al. 1999; Saffran et al. 1996). However, in order to produce meaningful novel utterances, children also need to assign meaning and function to these segments. Moreover, the segments need to be grouped into categories on the basis of which they can be recombined. By definition, this categorization process involves a process of abstraction. The fact that children develop productivity in their use of language demonstrates that they are making *some* segmentation and *some* abstraction. However, whether children readily divide

utterances from the input into the *smallest* possible linguistic units, and just *how* abstract or item-specific the categories or groupings of the linguistic units are, are matters of ongoing debate in the field of language acquisition.

One main issue in this debate is the role of frequency. More specifically, the question is whether there are any interactions between specific linguistic structures and specific morphological or lexical items, some of which are used in these structures to a much greater extent than others. Most proponents of generative grammar argue that the frequency with which specific items occur in specific structures plays almost no role in the development of productive rules and the representation of structures (e.g. Marcus et al. 1992; Roeper 2007). Specifically, it is assumed that children are operating with abstract structures from the start that can—in principle—be used with a great variety of morphological and lexical items. Usage-based and constraint-based lexicalist approaches, on the other hand, argue that the statistical distribution of specific items within and across specific structures is one of the key factors driving the acquisition, production, and comprehension of linguistic structures (e.g. Bybee 2006; Goldberg 2006; Langacker 2000; MacDonald 1999; Tomasello 2000). For language acquisition, in particular, it is argued that frequency determines how productive children are with specific linguistic structures, and how abstract their representations of these structures are. However, it is important to note that even proponents of the latter approaches do not claim that frequency is the *only* factor that determines the level of productivity and abstraction in children's and adults' production and comprehension of linguistic structures (for an overview see Ambridge 2010).

For example, Ambridge, Pine, Rowland, and Young (2008) demonstrated that both frequency and semantic class have an impact on how adults and children treat overgeneralization errors in a grammaticality judgment task. In support of Braine and Brook's (1995) entrenchment hypothesis, adults and children, at the age of 5;0–6;0 and 9;0–10;0, were found to be more sensitive to overgeneralization errors with high frequency intransitive verbs (e.g. *disappear him*) than to ungrammatical uses of low frequency or novel intransitive verbs (e.g. *vanish him*) (see also Theakston 2004). However, in support of Pinker's (1989) semantic verb class hypothesis, especially the older participants also judged ungrammatical transitive uses of intransitive verbs that express "semi-voluntary expression of emotion" (e.g. *giggle him*) to be worse than ungrammatical transitive uses of intransitive verbs of "directed motion" (e.g. *fall him*) or "going out of existence" (e.g. *vanish him*).

Furthermore, studies on productivity in morphology have shown that frequency interacts with regularity. Frequent verbs tend to be irregular and resistant to analogical change and regularization, whereas infrequent verbs tend to be regular; i.e. they are inflected by a productive rule (e.g. Bybee 1995; Rumelhart and McClelland 1987). Put the other way around, irregular patterns tend to

be used with frequent verbs, whereas regular patterns and productive rules tend to be used with infrequent verbs. In order to explain the interaction between frequency and regularity as well as other frequency effects in language use and acquisition, one has to distinguish between type and token frequencies. In considering specific morphological or syntactic patterns, token frequency tells you how many times a specific item is used in a specific pattern, whereas type frequency tells you how many different items are used in a specific pattern. Patterns that are mostly used with just one or two specific high frequency items are likely to be unproductive. These patterns are not readily used with novel items. Patterns that are used with many different items, on the other hand, tend to be productive. These patterns or rules are more likely to be used with novel items (e.g. Brooks and Tomasello 1999; Bybee 2006; Clark 1987; Goldberg 2006).

One process leading to low productivity of patterns that are frequently used with a limited number of specific items is chunking. When specific morphological or lexical items are frequently used together in a pattern, they are likely to be represented and processed as one unit or chunk, which is not constructed or analyzed on the basis of an abstract morphological or syntactic structure for every usage or comprehension event (e.g. Bannard and Matthews 2008; Bybee 1995; Bybee 2010; Bybee and Scheibman 1999; Pierrehumbert 2001). Therefore, the use of highly entrenched units or chunks does not necessarily support the acquisition of productive rules and abstract linguistic structures. Chunking is evident both in diachronic and ontogenetic language development. In grammaticalization, highly entrenched chunks develop meanings independent of their parts and combinations; i.e. they are no longer analyzed as instantiations of a productive linguistic pattern (e.g. Hopper and Traugott 1993). In the case of language acquisition, it has been argued that children often start with formulaic, entrenched units. For example, they start with a chunk like *whatsthat* before they segment this string into *what-is-that* and analyze it as an instance of a wh-question involving abstract word categories, such as wh-word, copula, and demonstrative (cf. Dąbrowska and Lieven 2005; Rowland 2007).

As children grow older, wh-questions and other syntactic constructions become more item-general and productive, i.e. they are used with a greater variety of morphological and lexical items. In order for generalization and abstraction to take place, children need to get a fair amount of input. They only start to insert specific lexical items into specific syntactic patterns after they have heard their caregivers use these items in these patterns, or after they have heard the patterns being used with a variety of lexical items, i.e. different types, which allows them to develop more item-general representations of the syntactic structures (see Tomasello 2000; Tomasello 2003 for overviews). For example, they might have to hear *what's that*, *where's that*, and *who's that* in order to discover a wh-word category and fill the wh-word slot with similar

items to produce novel strings such as *how's that*. According to the usage-based approach, it can only be assumed that children are operating with abstract linguistic structures when they start to break up item-specific chunks or patterns and use them with a variety of items, or when they comprehend linguistic structures when they are used with items that do not (frequently) occur in these structures in the input.

1.2. *Complement-clause constructions*

A good way to further test the different impacts of type and token frequencies in language development is to compare two constructions that greatly differ in type and token frequencies. One construction that has been shown to be item-specific and display high token frequencies and low type frequencies in children's input is the complement-clause construction (see for example Brandt et al. 2010; Diessel 2004; Diessel and Tomasello 2001).

Theoretically, complement-clause constructions can be analyzed as instances of transitive constructions that just take whole sentences as objects or some other kind of predicate argument (e.g. Noonan 1985). In that case, one views constructs like *I promise I will be on time* as instantiating the same pattern as *he promised it* and other simple transitives like *he built it.* One thus generalizes, grammatically speaking, over pronouns and clauses (e.g. *it* and *I will be on time*), as well as their relationships to their respective verbs; functionally speaking, one views complement-clause constructions as basically describing events. Based on data from spontaneous speech, however, it has been argued that most complement-clause constructions do not serve the same function as transitive clauses. That is, complement-taking phrases such as *I think* or *I promise* do not refer to events of thinking or promising. They are rather used to express speakers' epistemic, evidential, or evaluative stance towards the proposition expressed in the complement clause. Furthermore, in most cases, the complement clause does not function as a direct object of the complement-taking phrase. It rather describes the main event and functions like an assertive transitive clause.

Corpus studies have also demonstrated that the majority of complement-taking phrases are used with a limited number of specific subjects and verbs, and it has been suggested that most instances of complement-taking phrases can be analyzed as lexically specific strings or chunks, which are independent of abstract representations of transitives or complement-clause constructions (e.g. Diessel 2004; Thompson 2002; Thompson and Mulac 1991; Verhagen 2005).

However, it is important to note that complement-taking phrases containing a variety of less frequent verb and subject types, such as *Peter assumed* or *they realized*, are not absent from children's input. These instances are just not as

frequent as lexically specific complement-taking phrases such as *I think* (cf. Diessel 2004; Verhagen 2005). Children should thus be able to learn an abstract complement-clause pattern such as SUBJ VERB *(that)* X and use this pattern with a variety of complement-taking verbs and different subject types; however, we expect this learning and generalization process to be slow because it takes time for children to hear enough of these rather infrequent instances containing a variety of complement-taking verb and subject types.

Similarly, although it has been argued that most complement-taking phrases serve another function than just simple transitive predicates, children will also find some instances of complement-clause constructions in their input that are functionally similar to simple transitives (cf. Boye and Harder 2007). The distinction between the communicative functions of complement-clause constructions and simple transitives becomes weaker when we turn to complement-taking phrases with 3SG or plural subjects and less frequent verbs. At least for some cases, children might then be able to use their knowledge of simple transitive predicates to produce novel complement-taking phrases, especially when acquiring more and more verbs that occur in both environments (e.g. *know*, as in both *he knew that she stole the money* and *he knew the truth*). Complement-taking phrases describing events and functioning like simple transitives, however, are rare. In the Dutch newspaper corpus consulted by Verhagen (2005: 112), they amount to somewhat less than 5%. It may, then, take some time for children to use their representations of simple transitive constructions to produce novel complement-clause constructions.

1.3. *Development of complement-clause constructions*

Studies that have looked at children's early production of complement-clause constructions in spontaneous speech have shown that nearly all of their first complement-taking phrases can be described as entrenched units or fixed formulas functioning as epistemic markers or attention getters (Bloom et al. 1989; Brandt et al. 2010; Diessel 2004). Around the age of 3;0, at a time when children's knowledge of simple transitive constructions has already reached a fairly abstract, item-general level (cf. Fisher 2002; Tomasello 2000), they still tend to use only a limited number of specific, frequent verb and subject types in complement-taking phrases, and there is no evidence that children have developed an abstract pattern such as SUBJ VERB *(that)* X to produce novel complement-clause constructions. For example, Diessel (2004) has shown that one English-speaking child used the complement-taking verb *think* only in the fixed phrase *(I) think* X before the age of 3;7. However, whereas children's knowledge of the simple transitive construction has been extensively investigated through both corpus and experimental studies and through both production and comprehension measures (see Fisher 2002; and Tomasello 2000

for overviews), the claim that young children's knowledge of complement-clause syntax is item-specific is largely based only on corpus data. As discussed elsewhere, corpus data are always limited by sampling issues, small number of very specific contexts, limited number of children, etc. (cf. Behrens 2008).

The few experimental studies that investigated children's knowledge and level of representation of complement-clause constructions have either tested comprehension (e.g. de Villiers 1999) or used sentence repetition (Dąbrowska et al. 2009; Kidd et al. 2006). Kidd et al. (2006) asked English-speaking children between the age of 2;10 and 5;8 to imitate grammatical and ungrammatical complement-clause constructions with high and low frequency complement-taking verbs. The authors found that children were better at imitating and correcting test items with high frequency verbs (e.g. *I think* X) than with low frequency verbs (e.g. *I pretend* X) (for similar results see Dąbrowska et al. 2009). However, Kidd et al. (2006) also found that children often replaced the low frequency complement-taking verbs with high frequency complement-taking verbs and took this as evidence that even younger children have at least a semi-abstract knowledge of the complement-clause construction.

Looking at complex questions with complement clauses involving long-distance dependencies, such as *what did the girl say she bought?*, de Villiers (1999) showed that children under the age of 4;0 do not answer these correctly and concluded that they do not fully master the syntax and meaning of complement clauses before their fourth birthday. Dąbrowska et al. (2009) suggest that children's difficulty with such complex questions can in part be explained by prototype and frequency effects. That is, the vast majority of questions with long-distance dependencies found in the input of English-speaking children take the form of either *what do you think* X or *what did you say* X. In an experimental setting, children between the age of 4;6 and 6;9 were best at imitating complex questions that were formed according to these most frequent, prototype exemplars. Similarly, Dąbrowska (2008) and Ambridge and Goldberg (2008) showed that adults judge questions with complement clauses and long-distance dependencies containing the frequent complement-taking verbs *think* or *say* to be more acceptable than complex questions with less frequent complement-taking verbs, such as *whisper* (e.g. *what did Jess whisper that Dan bought*?).

Dąbrowska (2008) and Dąbrowska et al. (2009) suggest that non-prototypical instances of these complex questions are more difficult because they have to be "derived" from an item-specific prototype or formula. For example, in order to produce the non-prototypical exemplar *what does the man really hope they will like?*, the complement-taking verb *think* in the prototype exemplar has to be replaced by the verb *hope*, the subject *I* has to be replaced by *the man*, etc. (see also Verhagen 2006).

Ambridge and Goldberg (2008) offer an alternative explanation. They propose that questions with long-distance dependencies containing high frequency or prototypical complement-taking verbs such as *think* or *say* are more acceptable than complex questions with other complement-taking verbs because the high frequency verbs *think* and *say* are so-called bridge verbs. Unlike factive verbs, such as *remember*, or manner-of-speaking verbs, such as *whisper*, these semantically light bridge verbs are most often used with assertive, i.e. non-subordinate, complement clauses, and only assertive complement clauses allow extraction to form questions with long-distance dependencies. So the prototype effects observed in these studies are probably due to both frequency and discourse function. Presumably, these two factors also interact. As mentioned previously, frequently used complement-taking phrases are likely to turn into epistemic, evidential, or evaluative stance markers that are used with assertive, i.e. non-subordinate, complement clauses, which allow extraction.

Assertive complement clauses do not only allow extraction, they are also conceptually less complex than truly subordinate complement clauses, i.e. clauses representing a proposition that is only accessible through the mental space of the matrix clause subject and not directly from the mental space of the speaker. Truly subordinate complement clauses refer to beliefs or propositions that can be true or false. Classic false-belief tasks have shown that most children below the age of 4;0 are unable to describe or take into account their own or another person's knowledge state, especially when that knowledge state differs from reality (e.g. Wellman et al. 2001; Wimmer and Perner 1983). The majority of complement-clause constructions found in young children's spontaneous speech are assertive rather than subordinate. Children's first mental verbs do not really refer to mental states, and it has been shown that children start by using mental-state terms to refer to their own beliefs, and that these beliefs are mainly true (Bartsch and Wekkman 1995; Shatz et al. 1983).

This specific function of complement-clause constructions is tied to formal properties. Previous corpus studies on English and Dutch adult speech have shown that especially frequent mental-state complement-taking verbs, such as *think* or *know*, tend, almost exclusively, to co-occur with 1SG or 2SG pronominal subjects (e.g. Scheibman 2001), and it has been suggested that these frequent strings have turned into formulaic, entrenched units that are functionally and formally independent of a productive schema for complement-clause constructions such as SUBJ VERB *(that)* X (e.g. Thompson and Mulac 1991; Verhagen 2005). The present study first looked at a corpus of German child-directed speech to see (1) whether there is also evidence for these formulaic, entrenched units with mental-state terms in German children's input, and (2) whether there are similar patterns with communication complement-taking verbs, such as *say*, and simple transitive verbs, such as *eat* or *drink*.

2. Corpus study

The input data come from the Leo corpus, which consists of 383 one-hour recordings of child-adult interactions between the age of 2;0 and 5;0. Overall, the corpus includes nearly half a million words and 6300 diary utterances. All the child's utterances were automatically tagged by a German version of the CHILDES MOR-program (MacWhinney 2000), developed by Behrens (2000), and linked to the corresponding sound files. Of the input, only about 30% of the utterances were available in tagged form. The current study is based on these tagged utterances only. The input sample comes from different age periods (of the child). Furthermore, we analyzed only the mother's data because she is the primary caregiver.

Based on a previous corpus study of German complement-clause constructions, where some of the same corpus data as well as corpora from three additional German children were analyzed (Brandt et al. 2010), we chose to look at three communication verbs and three mental-state verbs that are frequently used with sentential complements by adults and children: *sagen* 'say', *erzählen* 'tell', *hören* 'hear', *glauben* 'believe', *denken* 'think', and *meinen* 'mean'. In addition, we chose three communication and mental-state verbs that are less frequently used with sentential complements: *singen* 'sing', *schreien* 'shout', *berichten* 'report', *schätzen* 'guess', *vermuten* 'presume', and *fürchten* 'be afraid'. Some of these verbs rarely occur with sentential complements, but all of the items have been found to occur as matrix verbs in German children's complement-clause constructions (Brandt et al. 2010). Finally, we also looked at three frequent and three less frequent, but semantically similar, simple transitive verbs: *essen* 'eat' and *naschen* 'nibble', *malen* 'paint' and *zeichnen* 'draw', as well as *trinken* 'drink' and *schlürfen* 'slurp' (see Table 1).

Since the frequent complement-taking verbs are most often used in the present tense (cf. Brandt et al. 2010; Diessel 2004), and since we are interested in the most frequent and entrenched complement-taking phrases, we focused our input analysis on present-tense verbs and calculated the number of subject types that these verbs co-occur with. Table 1 shows how many times the verbs are used with 1SG or 2SG pronouns, 3SG pronouns or NPs, and plural pronouns or NPs in German child-directed speech (CDS).

The frequent simple transitive verbs are used with a great variety of subject types, and their distribution across subject types is relatively even. This is also indicated by the Shannon-Weaver values in the rightmost column. The Shannon-Weaver value is an entropy measure to determine how evenly a given item is distributed, taking into account its overall frequency ($H' = \Sigma(Pi*\log_{10}(Pi))$; where Pi = percentage of verb tokens covered by a specific subject type). For example, a given verb might occur with four different subject types. If it is predominantly used with just one of these four different types and the distribution

Table 1. *Co-occurrence of present-tense verbs and subject types in German CDS.*

	freq	verb	1SG	2SG	3SG	PL	sum	Shannon Weaver
transitive	high	*essen* 'eat'	8	20	69	49	146	0.84
		malen 'paint'	22	30	13	23	88	0.90
		trinken 'drink'	4	8	16	5	33	0.89
	low	*naschen* 'nibble'	0	0	0	0	0	n/a
		zeichnen 'draw'	0	0	0	0	0	n/a
		schlürfen 'slurp'	0	0	0	0	0	n/a
communication	high	*sagen* 'say'	50	51	216	29	346	0.69
		erzählen 'tell'	4	18	5	1	28	0.71
		hören 'hear'	6	24	7	5	42	0.75
	low	*singen* 'sing'	0	0	4	6	10	0.99
		schreien 'shout'	0	2	5	0	7	0.86
		berichten 'report'	0	0	0	0	0	n/a
mental-state	high	*glauben* 'believe'	1010	12	1	6	1029	0.07
		denken 'think'	121	8	20	5	154	0.46
		meinen 'mean'	43	357	6	3	409	0.33
	low	*schätzen* 'guess'	10	0	1	0	11	0.44
		vermuten 'presume'	15	1	1	0	17	0.40
		fürchten 'be afraid'	24	0	0	1	25	0.24

is skewed, it will get a low Shannon-Weaver value. If the verb occurs with each of these four subject types with almost equal frequency, it will get a high Shannon-Weaver value. The infrequent transitive verbs were selected because they are semantically similar to the high frequency transitive verbs, but, appar-

ently, they were not used in the present tense in the input sample. We will come back to this issue in the discussion of item effects in Section 4.3.

The frequent communication verbs are also used with a variety of subject types. However, the distribution across subject types is more skewed for these verbs than for the frequent transitive verbs. They are predominantly used with either 3SG or 2SG subjects. The Shannon-Weaver values in Table 1 also indicate that the distribution of the frequent communication verbs is more skewed than the distribution of the infrequent communication verbs. No such difference between frequent and infrequent items is seen for the mental-state verbs. Both high and low frequency mental-state verbs are mainly used with just 1SG pronouns or 2SG pronouns. Moreover, compared to the other verb classes, the mental-state verbs show the most skewed distribution as indicated by the low Shannon-Weaver values.

2.1. *Predictions*

In our experiment, we tested four- and five-year-old German-speaking children's productivity with simple transitive verbs in coordinate constructions and their productivity with mental-state and communication verbs in complement-clause constructions by prompting them to change the subject of these verbs from 1SG to 3SG. Based on previous experiments that tested children's representation and productive use of transitive constructions (see for example Tomasello 2000) as well as complement-clause constructions (e.g. Kidd et al. 2006), we should predict for both constructions that children will be better when the sentences contain high frequency verbs. However, in the current study, children are not only required to produce novel utterances. In order to do so, they also need to break up phrases, some of which are probably processed as one unit or chunk. The analysis of German CDS has shown that, in the present tense, mental-state complement-taking verbs, such as *glauben* 'believe', very often co-occur with 1SG or 2SG pronominal subjects. They are rarely used with any other subject types. Because of this skewed distribution and high token frequencies we would predict that young children find it hard to break up subject-verb chunks such as *ich glaube* 'I believe'. They are likely to be entrenched and processed as one unit without any formal or functional ties to more abstract and productive patterns such as SUBJ *believes (that)* X or SUBJ VERB *(that)* X. Communication complement-taking verbs and especially simple transitive verbs, on the other hand, are used with a greater variety of subject types and the distribution across subject types is less skewed. This should enable children to form semi-abstract patterns for complement clauses and simple transitives, such as SUBJ *says (that)* X or SUBJ *eats* X, and they should therefore find it easier to change the subjects of items belonging to these verb classes.

Moreover, we expect to find interactions between verb class and frequency. The input data suggest that both high and low frequency mental-state verbs are likely to be used in entrenched units containing a 1SG or 2SG pronominal subject. When we look at the communication complement-taking verbs, however, the infrequent items are more evenly distributed across subject types than the frequent items. Children should thus be more likely to have formed semi-abstract patterns with low frequency communication verbs than with high frequency communication verbs.

Finally, Table 1 also shows that some verbs (e.g. *essen* 'eat') are more often used with 3SG subjects than others. Therefore, children might also find it easier to change 1SG subjects to 3SG for these specific verbs. We tested these predictions with an elicited production task.

3. Elicited production

3.1. *Participants*

Thirty-nine ($N = 39$) four-year-old and 26 five-year-old German-speaking children were recruited from nurseries in Leipzig. We excluded eleven four-year-olds and two five-year-olds from the main analysis because they never produced any of the target verbs with a 3SG subject. They either dropped the subject or repeated the 1SG pronominal subject. The main analysis is thus based on 28 four-year-olds (range = 4;0–4;4, mean = 4;2) and 24 five-year-olds (range = 5;0–5;5, mean = 5;3), who responded with a target verb together with a 3SG subject at least once. Subsequent analyses of errors are based on the whole sample of children. All were native monolingual speakers of German; none had any known language impairment.

3.2. *Materials*

We tested two main factors: verb class (simple transitive verbs vs. communication complement-taking verbs vs. mental-state complement-taking verbs) and frequency (high vs. low). This resulted in six conditions. We had three test sentences in each condition. Based on the current and previous corpus analyses (see Brandt et al. 2010; and Table 1), we chose three different verbs for each condition (see Appendix A). So each test sentence contained a different simple transitive verb or complement-taking verb. One test sentence from each condition is shown in Table 2.

The first part of the test sentences—the part that the children were prompted to change—was always the 1SG pronominal subject *ich* 'I' presented together with a present-tense verb from one of the three verb classes. The test items were constructed to be as equal as possible. First of all, they were controlled for length. This was done by adding adverbials, such as *noch* 'still', *gleich* 'in

Table 2. *Conditions and example sentences.*

	frequent	infrequent
transitive	*Ich trinke Kaffee und Emma besucht die Oma.* 'I'm drinking coffee and Emma is visiting the grandma'	*Ich schlürfe Tee und Emma besucht die Tante.* 'I'm slurping tea and Emma is visiting the aunt'
communication	*Ich sage, dass Emma gleich zum Zoo geht.* 'I say that Emma will go to the zoo in a minute'	*Ich singe, dass Emma noch zum Zirkus geht.* 'I sing that Emma will still go to the circus'
mental-state	*Ich glaube, dass Emma morgen ein Haus baut.* 'I believe that Emma is building a house tomorrow'	*Ich schätze, dass Emma jetzt einen Turm baut.* 'I guess that Emma is building a tower now'

a minute', or *jetzt* 'now', to some of the sentences. We also controlled for number of verbs. The sentences with communication and mental-state complement-taking verbs naturally contain two verbs (the complement-taking verb and the verb in the complement clause). We therefore presented the simple transitive verbs in coordinate structures, which also contain two verbs. Furthermore, one frequent item from one verb class was always paired with an infrequent item from the same verb class, and both items were presented with the same subordinate or coordinate verb (for example, 'I **believe** that Emma is **building** . . .' was paired with 'I **guess** that Emma is **building** . . .').

The test sentences were presented in four different pseudo-randomized orders. A first randomized block containing one item from each of the six conditions was presented before a second and third randomized block containing one item from each of the six conditions. This way, a maximum of two items from within the same condition could proceed one another.

3.3. *Procedure*

The children were tested in a quiet room in their nurseries. The test sentences were pre-recorded and presented to the children by two talking dogs (Susi and Fido). One spoke with a female voice, and the other with a male voice. The experimenter played the sentences from an iPod, which was hidden under the table and connected to two small speakers hidden inside the dogs.

The children were told that the dogs were going to tell them and the experimenter some stories about themselves and their sister (Emma), who had been introduced and shown on a picture beforehand. The experimenter also brought some sheets of paper with pictures on them and said that they should write

down these stories about the dogs. She asked the child to listen very carefully to what the dogs were saying and then to report this to the experimenter, who needed the child's help because she was busy writing. In order to make the child change the 1SG pronominal subject in the test sentence and prompt a response with a 3SG subject, the experimenter asked a question that focused on the dogs. That is, before a dog started speaking, she (or sometimes the child) asked: *Fido/Susi, was passiert bei dir?* 'Fido/Susi, what's up with you?'. After the dog finished the sentence (e.g. *ich glaube, dass Emma morgen ein Haus baut* 'I believe that Emma is building a house tomorrow'), the experimenter asked again: *Was passiert bei dem/der?* 'What's up with him/her?'.

This procedure was introduced and practiced with six warm-up trials including simple transitive, communication, and mental-state verbs that were presented in less complex structures and shorter phrases than in the test phase. One of the dogs, for example, said ***ich*** *weiss ganz viel* '**I** know a lot' or ***ich*** *rede immer viel* '**I** always talk a lot'. After the dog uttered one of these sentences, the target response was ***(d)er*** *weiss ganz viel* '**he** knows a lot' or ***(d)er*** *redet immer viel* '**he** always talks a lot'. All children changed the subjects of the verbs in the warm-up phase at least once before the experimenter continued with the test. None of the verbs from the warm-up sentences re-occurred in the test phase.

In the test phase, children were required to change an utterance such as (1) into an utterance such as (1a):

(1)	***ich***	***glaube,***	*dass*	*Emma*	*morgen*	*ein*	*Haus*	*baut.*
	I	believe	that	Emma	tomorrow	a	house	builds
	'**I** believe that Emma is building a house tomorrow.'							
(1a)	***(d)er/ Fido***	***glaubt,***	*dass*	*Emma*	*morgen*	*ein*	*Haus*	
	he/ Fido	believes	that	Emma	tomorrow	a	house	
	baut.							
	builds							
	'**He/ Fido** believes that Emma is building a house tomorrow.'							

The children, however, could and did respond in many different ways. What we were interested in for the main analysis is whether or not they responded with the target verb together with a 3SG subject, which involves breaking up the chunk of a 1SG pronominal subject and the target verb. Whether children also provided the rest of the sentence (i.e. the subordinate clause or the second part of a coordinate structure) was not considered for the main analysis, but will be addressed in further analyses to follow. To repeat from examples (1) and (1a), what was considered for the main analysis was whether or not the children changed ***ich*** *glaube* X '**I** believe X' into ***(d)er*** *glaubt* X '**he** believes X' or ***Fido*** *glaubt* X '**Fido** believes X'.

3.4. *Statistical model for main analysis*

Since the response variable was binomial (did vs. did not respond with the target verb and a 3SG subject) and since we had repeated observations of the same subjects, we used a Generalized Linear Mixed Model (GLMM) (Baayen 2007). Into this we included as fixed effects the covariates age and 3SG frequency (how often the target verb is used with a 3SG subject in CDS), and the categorical variables verb frequency (high or low) and verb class (transitive, communication, or mental-state), and as random effects subject and item (individual verbs). In addition, we included all two-way interactions between age, verb frequency, and verb class and also their three-way interaction. We fitted the models in R (R-Development-Core-Team 2008) using the function lmer of the package lme4 (Bates et al. 2008), with binominal family, logit link function, and maximum likelihood fitting (argument REML = false). We tested for significance using likelihood ratio tests (Dobson 2002) whereby we compared the fit of a full model with that of a corresponding reduced model using the R function anova with argument test = "chisq". We first established the significance of the global model by comparing the fit of the full model with that of the null model comprising only the random effects. We then tested the significance of the interactions, beginning with the three-way interaction, and removed interactions when they were not significant. Prior to model fitting we log-transformed the 3SG frequencies.

4. Results

4.1. *Main analysis*

Twenty-eight ($N = 28$) of the four-year-old children and 24 of the five-year-olds responded with a target verb and a 3SG pronominal subject at least once and were entered into the main analysis. Although we grouped the individual verbs into three classes (transitive vs. communication vs. mental-state) and two frequency groups (high vs. low), we found significant item effects (χ^2 [1] = 5.7259; $p = 0.02$). That is, for example, some specific high frequency transitive verbs caused more difficulty than other high frequency transitive verbs. These item effects will be described and discussed in more detail in Section 4.3.

Figure 1 shows the proportion of trials (of all trials) in each condition where the children responded with the target verb and a 3SG subject. The five-year-olds performed better overall. As expected, both four- and five-year-olds performed better on the high frequency transitive verbs than on he low frequency transitive verbs (4-year-olds: 63% vs. 27%; 5-year-olds: 76% vs. 47%). In the conditions with mental-state verbs, however, children from both age groups performed equally well on the high and low frequency items (4-year-olds: 21% vs. 24%; 5-year-olds: 54% vs. 53%). In the conditions with communication

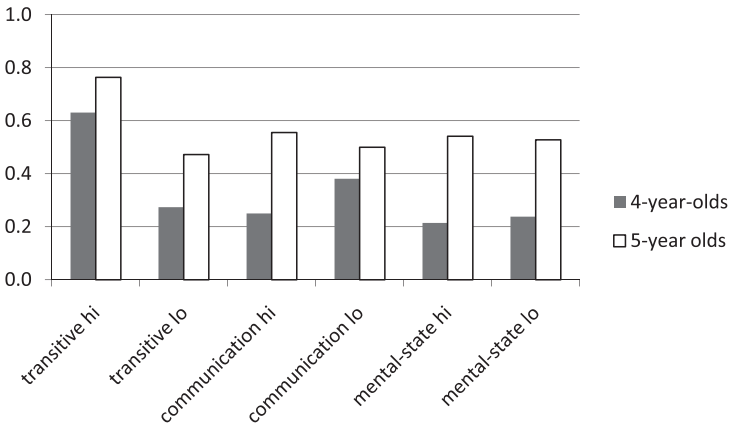

Figure 1. *Responses with target verbs and 3SG pronominal subjects.*

verbs, the younger children even performed better on the low frequency items than on the high frequency items (38% vs. 25%), whereas the older children performed equally well on low and high frequency items (50% vs. 56%).

The three-way interaction between age, verb class, and frequency was not significant (χ^2 [2] = 3.5936; p = 0.166) and hence was removed from the model. We found a trend for an interaction between age and verb class (χ^2 [2] = 4.6663; p = 0.097), indicating that verb class did not have exactly the same effect on the older children's performance as on the younger children's performance. As indicated in Figure 1, the difference between the (high frequency) transitive verbs and the other conditions was greater for the four-year-olds than for the five-year-olds. Finally, we found a significant interaction between verb class and frequency (χ^2 [2] = 13.822; $p < 0.001$). This interaction is driven by the fact that both the four-year-olds and the five-year-olds performed better on the high frequency transitive verbs than on the low frequency transitive verbs (Wilcoxon exact test: 4-year-olds: T^+ = 291.5; N = 24 [4 ties]; $p < .001$; 5-year-olds: T^+ = 130.5; N = 16 [8 ties]; $p < .001$). For the communication and mental-state complement-taking verbs, however, we found either reverse or no frequency effects. The four-year-olds showed a strong tendency to perform better on the low frequency communication verbs than on the high frequency communication verbs (Wilcoxon exact test: T^+ = 115.5; N = 17 [11 ties]; p = .058), but they showed no such frequency effects for the mental-state verbs (Wilcoxon exact test: T^+ = 30.5; N = 10 [18 ties]; p = .807). The five-year-olds did not show any frequency effects for the communication verbs (Wilcoxon exact test: T^+ = 47.5; N = 12 [12 ties]; p = .556); neither did they show any frequency effects for the mental-state verbs (Wilcoxon exact test: T^+ = 30.0; N = 10 [14 ties]; p = 1).

Table 3. *Percentage of children who succeeded at least once in each condition.*

		4-year-olds	5-year-olds
transitive	high	89.29%	95.83%
	low	57.14%	79.17%
communication	high	42.86%	70.83%
	low	67.86%	70.83%
mental	high	32.14%	66.67%
	low	35.71%	66.67%

4.2. *Sub-analyses: success rate, structure, and verb replacement*

Similar patterns can be seen when we determine the percentage of children who succeeded at least once in a specific condition. Overall, only 21% (6/28) of the four-year-olds and 50% (12/24) of the five-year-olds succeeded at least once in each of the six conditions. However, almost 90% of the younger children and 96% of the older children succeeded at least once in the condition with high frequency transitive verbs, whereas, for example, only 32% of the younger children and 67% of the older children succeeded at least once in the condition with high frequency mental-state verbs (see Table 3). This measure also indicates the same interactions between verb class and age as well as verb class and frequency as indicated previously. For example, the percentage of four-year-olds who scored at least once is higher for the condition with low frequency communication verbs than it is for the condition with high frequency communication verbs. However, no such frequency effects are found in the younger children's performance on mental-state verbs. Moreover, the older children do not show frequency effects in any of the conditions involving complement-clause constructions.

As has been suggested to us by a reviewer, differences between the conditions with transitive or communication verbs and the conditions with mental-state verbs could also be explained by differences in verb semantics. Specifically, our elicitation question (*Was passiert bei dem/der?* 'What's up with him/her?') might be more appropriate for responses involving simple transitive or communication verbs because it presupposes a dynamic event. In the conditions with the mental-state verbs, it might be more appropriate to state what is happening; i.e. what is expressed in the complement clause, instead of saying what the dog thinks (is happening) in response to that question.

We analyzed the structures of the children's responses to see whether they responded with the target verb and the complement or coordinate clause, whether they just responded with the complement or coordinate clause, or whether they responded with an ungrammatical fragment. The answers of all

Table 4. *Structure of responses.*

		subordinate/ coordinate structure		only subordinate/ coordinate		fragment	
		4;0	5;0	4;0	5;0	4;0	5;0
transitive	high	80.3%	92.3%	9.4%	5.1%	10.3%	2.6%
	low	67.5%	87.2%	16.2%	5.1%	16.2%	7.7%
communication	high	39.3%	76.9%	15.4%	6.4%	45.3%	15.4%
	low	41.9%	74.4%	14.5%	5.1%	43.6%	18%
mental	high	33.4%	73.1%	11.1%	5.1%	55.6%	21.8%
	low	35.9%	71.8%	11.1%	5.1%	52.1%	23.1%

39 four-year-olds and 26 five-year-olds who took part in and finished the study were included in this analysis. The children mostly responded either with a full coordinate/ subordinate target structure or with an ungrammatical fragment (see Table 4). The younger children in particular often just repeated the last few words or parts of the main clause and parts of the subordinate or coordinate clause without integrating these two parts syntactically, yielding an ungrammatical fragment. Both four- and five-year-olds were more likely to respond with ungrammatical fragments in the conditions involving subordination than in the conditions involving coordination. In the conditions with high frequency verbs, for example, we found more ungrammatical fragment responses for the communication verbs than for the transitive verbs (Wilcoxon exact: 4-year-olds: $T^+ = 399.5$; $N = 28$ [11 ties]; $p < .001$; 5-year-olds: $T^+ = 28$; $N = 7$ [19 ties]; $p = .016$) and more ungrammatical responses for the mental-state verbs than for the transitive verbs (Wilcoxon exact: 4-year-olds: $T^+ = 429.5$; $N = 29$ [10 ties]; $p < .001$; 5-year-olds: $T^+ = 45$; $N = 9$ [17 ties]; $p = .004$). No significant difference was found between high frequency mental-state verbs and communication verbs for either the four-year-olds or the five-year-olds. Note that all test sentences were of the same length. This indicates that, besides frequency and diversity, syntactic (and semantic) complexity is an additional factor influencing children's responses in our task.

Both four- and five-year-olds also sometimes dropped the first part of the transitive coordinate structures or they dropped the main clause of the complement-clause constructions and transformed the subordinate clause into a main clause, which involves word-order changes in German:

(1) *ich glaube, dass Emma morgen ein Haus* ***baut.***
I believe that Emma tomorrow a house builds
'I believe that Emma is building a house tomorrow.'

(1b) *Emma* ***baut*** *morgen ein Haus*.
Emma builds tomorrow a house
'Emma is building a house tomorrow.'

These changes are summarized under "only subordinate/ coordinate" in Table 4. If our elicitation question was more appropriate for answers focusing on dynamic events, as suggested by the reviewer mentioned previously, we should see more of these "only subordinate/ coordinate" responses in the conditions with mental-state complement-taking verbs than in the other conditions, but there are actually slightly more of these responses in the conditions with low frequency transitive and high and low frequency communication verbs. Using Wilcoxon exact tests, we did not find any significant differences between any of the conditions for this kind of response, either for the four-year-olds or for the five-year-olds.

We further analyzed all responses to see whether the children used, replaced, or dropped the target verbs in their responses. Again, these analyses are based on all 39 four-year-olds and 26 five-year-olds who took part in and finished the study. As was done for the main analysis, we only focused on the first part of the test sentences (i.e. main clauses in the complement-clause constructions or first part of the coordinate structures). Also note that these calculations are independent of whether the children used the verbs with a 3SG subject and/or in the target construction.

The younger children very often dropped the target verbs in the conditions involving complement-clause constructions. In most of these cases, they actually dropped the whole complement-taking phrase and just provided the complement clause or parts of the complement clause in their response. They also did not repeat low frequency transitive verbs very often. However, instead of just dropping infrequent transitive verbs, the children were equally likely to replace them with more familiar transitive verbs (see Table 5). Overall, the

Table 5. *Use of target verbs in children's responses.*

		same		replace		drop	
		4;0	5;0	4;0	5;0	4;0	5;0
transitive	high	80.3%	92.3%	6.8%	2.6%	12.8%	5.1%
	low	47.9%	61.5%	27.4%	29.5%	24.8%	9.0%
communication	high	41.9%	80.8%	6.0%	3.8%	52.1%	15.4%
	low	47.9%	67.9%	7.7%	20.5%	44.4%	11.5%
mental	high	35.0%	78.2%	5.1%	1.3%	59.8%	20.5%
	low	37.6%	70.5%	8.5%	10.3%	53.8%	19.2%

younger children were more likely to replace low frequency transitive verbs than high frequency transitive verbs (Wilcoxon exact test: $T^+ = 257$; $N = 23$ [16 ties]; $p < .001$), and they were more likely to replace low frequency transitive verbs than low frequency communication verbs ($T^+ = 247.5$; $N = 23$ [16 ties]; $p < .001$) or low frequency mental-state verbs ($T^+ = 226$; $N = 22$ [17 ties]; $p = .001$). This suggests that their representation of simple transitives is more verb-general than their representation of complement-clause constructions. The older children were more likely to replace the low frequency verbs than the high frequency verbs in all conditions, but this effect was also strongest for the transitive verbs (Wilcoxon exact test: transitives: $T^+ = 153$; $N = 17$ [9 ties]; $p < .001$; communication: $T^+ = 72.5$; $N = 12$ [14 ties]; $p = .005$; mental-state: $T^+ = 21$; $N = 6$ [20 ties]; $p = .031$). This suggests that, overall, the older children have developed more item-general representations of both transitive and complement-clause constructions. However, just looking at the low frequency items, the five-year-olds were also more likely to replace low frequency transitive verbs than low frequency mental-state verbs (Wilcoxon exact test: $T^+ = 137$; $N = 17$ [9 ties]; $p = .002$). This indicates that they have a stronger representation of transitives than complement-clause constructions (with mental-state verbs). No other pair-wise comparisons between conditions turned out to be significant. What is also shown in Table 5 is that, overall, the older children were much more likely to use the target verbs in their responses than the younger children. This increase in responses with target verbs is especially strong in the conditions with complement-clause constructions, where the older children provided about twice as many responses with target verbs as the younger children.

These results suggest that at the age of 4;0 the representation of transitive constructions is more verb-general than the representation of complement-clause constructions, but that the representation of complement-clause constructions also starts to become more verb-general between the age of 4;0 and 5;0. This developmental trend is also supported by the interaction between verb class and age reported in the main analysis.

4.3. *Item effects*

As mentioned previously, within some conditions, some items, i.e. specific verbs, caused more difficulties than others. Figures A through C in Appendix B show the proportion of trials with target responses, i.e. target verb plus 3SG subject, for each verb separately. The high frequency items are grouped on the left side of the graphs, and the low frequency items are grouped on the right. There is some variety within most of the conditions, but we will focus on the conditions that showed significant differences between items. Significant item effects were only found for the transitive and mental-state verbs.

The four-year-olds performed significantly worse on *malen* 'paint' than on the other two high frequency transitive verbs (*Cochran's Q* [2] = 7.0, $p = .038$); they also performed worse on *schlürfen* (slurp) than on the other two low frequency transitive verbs (*Cochran's Q* [2] = 6.5; $p = .037$), and they performed better on *schätzen* 'guess' than on the other two low frequency mental-state complement-taking verbs (*Cochran's Q* [2] = 7.0; $p = .039$). Like the younger children, the five-year-olds' performance varied across the three low frequency transitive verbs (*Cochran's Q* [2] = 8.133; $p = .019$), where they performed best on *zeichnen* 'draw', followed by *naschen* 'nibble', and *schlürfen* 'slurp'. The five-year-olds also showed a trend to perform better on *glauben* 'believe' than on the other two high frequency mental-state complement-taking verbs (*Cochran's Q* [2] = 7.0; $p = .058$).

At this point, we cannot offer a straightforward explanation that would cover all of these item effects. Interestingly, the younger children showed more item effects than the older children, which might suggest that the older children's representations of complement-clause and transitive constructions is more verb-general. One possible reason for some of the observed item effects is that we still have considerable variety within each frequency group. Both the younger and older children performed worse on *schlürfen* 'slurp' than on the other two low frequency transitive verbs. None of these low frequency verbs were found in the present tense in the German input sample (see Table 1). However, small differences in frequency can be seen when we consider all possible tense forms for these verbs. We then find four utterances with *naschen* 'nibble' and four utterances with *zeichnen* 'draw', but only one utterance with *schlürfen* 'slurp' in the input sample. Similar patterns can be found in the child's (Leo's) own speech, where we find nine instances of *naschen* 'nibble', ten instances of *zeichnen* 'draw', but only one instance of *schlürfen* 'slurp'. This item effect could thus be interpreted as support for the common assumption that children are more productive with high frequency items than with low frequency items (see for example Kidd et al. 2006; Tomasello 2000). Children might also have had problems with *schlürfen* 'slurp' because they did not know the semantics of this uncommon verb and thus were not sure about the appropriate argument structure (cf. Fisher 2002), and it is hard to disentangle the effects of frequency and semantics here.

Similarly, the high frequency mental-state complement-taking verb *glauben* 'believe' is far more frequent than the other two frequent mental-state complement-taking verbs (cf. Table 1), and this might explain why the five-year-olds had less difficulty changing the subject of *glauben* 'believe' than changing the subject of the other two frequent mental-state verbs. The younger children, however, did not perform better on *glauben* 'believe' than on the other high frequency mental-state complement-taking verbs. Moreover, *glauben* 'believe' is the verb that is, by far, most frequently used with 1SG

subjects and that shows the lowest degree of diversity in the input sample. As we have suggested previously, *ich glaube* 'I believe' is a processing chunk that should be hard to break up. Since we only found this item effect for the older children, the factor of overall (token) frequency and the factor of diversity or type frequency might play different roles at different points in development. Recall that the main analysis also showed that the four-year-olds' but not the five-year-olds' performance on the communication complement-taking verbs was partly determined by diversity. That is, the younger children performed better on low frequency communication verbs, which are more evenly distributed across subject types than high frequency communication verbs. It might very well be that early in development the acquisition of linguistic structures is supported by diversity, i.e. type frequency, whereas later in development the acquisition is more likely to be determined by token frequency. It has been proposed that high token frequencies and skewed distributions hinder the formation of abstract schemas in language (e.g. Bybee 2006). However, it has also been claimed that, for younger children in particular, surface similarities, e.g. overlap in verbs and/ or nouns, support the discovery of relational similarity in non-linguistic domains and the acquisition of abstract linguistic schemas (e.g. Casenhiser and Goldberg 2005; Childers and Tomasello 2001; Gentner and Medina 1998; Savage et al. 2003). The item effects and our overall results indicate that children's productivity with transitive and complement-clause constructions is affected both by token frequencies/surface similarity and type frequencies/diversity and we will come back to this issue in the discussion.

Finally, it is possible that some of the observed item effects are caused by the fact that, within most conditions, we had some verbs that are more frequently used with 3SG subjects than others (cf. Table 1). For example, the high frequency transitive verbs *essen* 'eat' and *trinken* 'drink' are more likely to be used with 3SG subjects than the high frequency transitive verb *malen* 'paint'. This difference might explain why the four-year-olds had more difficulty responding with *malen* 'paint' and a 3SG subject than changing the subjects of *essen* 'eat' and *trinken* 'drink' into 3SG. Note, however, that the factor of 3SG frequency did not turn out to be significant in the model used for the main analysis ($Z = -.447$; $p = .65$). That is, the number of times each verb (in present tense) is used with 3SG subjects cannot account for the overall results.

5. Discussion

To summarize, we tested four- and five-year-old German-speaking children's productivity with simple transitive verbs in coordinate constructions and their productivity with mental-state and communication verbs in complement-

clause constructions by prompting them to change the subject of these verbs. In accordance with earlier findings, children in both age groups were better at producing novel utterances with high frequency transitive verbs than with low frequency transitive verbs. Overall, children also produced more novel utterances with transitive verbs than with complement-taking verbs, which is probably due to the fact that (1) overall, transitive constructions are more frequent than complement-clause constructions and (2) transitive constructions are conceptually and syntactically less complex than complement-clause constructions. Most interestingly, however, we found reverse or no frequency effects for the complement-taking verbs. The four-year-olds were better at changing the subject of infrequent communication complement-taking verbs than changing the subject of frequent communication complement-taking verbs. They did not show any frequency effects for the mental-state complement-taking verbs. The older children did not show any frequency effects for any of the complement-taking verbs. The observed interaction between verb class and frequency is best explained by differences in diversity and the related issue of discourse function.

Our analysis of German CDS has shown that frequent transitive verbs are used with a greater variety of subject types than frequent communication complement-taking verbs, which again are used with a greater variety of subject types than frequent mental-state complement-taking verbs. Furthermore, infrequent communication verbs are used with a greater variety of subject types than frequent communication verbs. Infrequent mental-state verbs, however, are almost exclusively used with 1SG or 2SG pronominal subjects in German CDS. That is, infrequent mental-state verbs show the same skewed distribution across subject types as the frequent mental-state complement-taking verbs (cf. Table 1).

Both token frequencies and type frequencies (or diversity) affect the acquisition and formation of abstract schemas and constructions. First of all, particularly in early development, the discovery of relational similarity in linguistic and non-linguistic domains is supported by surface similarities (e.g. Childers and Tomasello 2001; Gentner and Medina 1998; Savage et al. 2003). For example, children are better at learning a novel syntactic construction when they hear many instances of that construction with the same verb (Casenhiser and Goldberg 2005). Furthermore, it has been suggested that the acquisition of fully abstract linguistic schemas starts with the acquisition of semi-abstract, item-specific schemas. These item-specific schemas develop out of exemplars of a specific construction that show some lexical overlap. Importantly, in order for some abstraction to take place the exemplars also have to differ from one another in some ways (Braine and Brooks 1995; Bybee 2006; Clark 1987; Goldberg 2006; Langacker 2000). For example, in order to form a semi-abstract schema such as SUBJ *pushed me*, children must hear transitive sentences with

the verb *push* used with a variety of subject types. If children only hear exemplars with the same verb *and* subject, they will be unlikely to develop a schema that can be used with novel subjects. Such item-specific strings are more likely to turn into processing chunks that are formally and functionally independent of more abstract schemas (cf. Bannard and Matthews 2008; Pierrehumbert 2001). As children grow up hearing many instances of the transitive construction with a variety of verbs every day, they should detect formal and functional similarities between item-specific strings, such as *she pushed me*, and more abstract schemas with other verbs, such as SUBJ VERB*ed me* or SUBJ *threw me*, that allows them to also use the verb *push* with novel subjects even though they only hear and use this specific verb with the pronominal subject *she*. In the context of the current study, this means, for example, that children almost never hear the complement-taking verb *believe* with subjects other than *I* and hence are unlikely to develop a semi-abstract schema such as SUBJ *believes* X. However, once they discover the functional and formal similarities between strings like *I believe* X and more abstract complement-clause schemas with other verbs like SUBJ *says* X, they should be able to also use a variety of subject types with the verb *believe*.

5.1. *Transitive verbs*

The children's performance on the transitive verbs shows how the development of abstract schemas can start with semi-abstract schemas. The frequency and item effects observed in both age groups suggest that the children have a stronger representation of the transitive when it is used with high frequency verbs. For example, they seem to have a stronger representation of SUBJ *eat* X than of SUBJ *nibble* X. The frequency and item effects might well be confounded with semantics. As has been suggested by Fisher (2002), for example, children might simply have difficulty producing novel utterances with novel or uncommon verbs because they do not know the meaning of these verbs and hence do not know how to use these verbs in the correct argument structure. However, unlike experiments that prompted children to transfer an unfamiliar verb from one argument structure to another (for an overview see Tomasello 2000), we only asked the children to change the subject of the verbs. The correct argument structure was provided in the prompt.

5.2. *Communication complement-taking verbs*

The younger children had more problems changing the subject of frequent communication complement-taking verbs than changing the subject of infrequent communication verbs. This reverse frequency effect is probably caused

by the fact that infrequent communication verbs show a less skewed distribution across subject types than frequent communication verbs. What is puzzling, however, is the fact that the younger children were not very successful in combining frequent communication verbs with a novel 3SG subject in their responses although this is actually the most frequent usage pattern in the input, especially when we look at the most frequent communication verb used with sentential complements, i.e. *sagen* 'say' (cf. Table 1). One possible explanation is that the children have not yet discovered the formal and/ or functional commonalities between the frequent and infrequent patterns (e.g. *der sagt* 'he says' vs. *ich sage* 'I say') to form a link and develop a semi-abstract schema such as SUBJ *say(s)* X. Alternatively, this result can be explained by the fact that the class of 3SG subjects contains a variety of types, including lexical NPs. Whereas 1SG and 2SG subjects are always expressed in the same forms, i.e. *I* or *you*, 3SG subjects can be expressed by *he*, *the sheep*, *dad*, etc., and the high frequency complement-taking verbs *sagen* 'say', *erzählen* 'tell', and *hören* 'hear' occur with a great variety of 3SG subject types in German CDS. For example, within a random sample of 50 tokens of *sagt* 'say-PRES-3SG' from Leo's input, this verb form occurs with 22 different 3SG subject types. Of these 22, seven are 3SG pronouns (*sie*, *die* 'she', *er*, *der* 'he', *man* 'one', *das* 'that', *wer* 'who'). The other 15 are lexical NPs, most of which only occur once. The usage patterns with communication complement-taking verbs may thus not be as entrenched as the usage patterns with mental-state complement-taking verbs. Nevertheless, they show less diversity and caused more difficulty than simple transitive patterns (with high frequency verbs) for both four- and five-year-old children.

Unlike the younger children, the five-year-olds showed no frequency effects in their performance on the communication complement-taking verbs. As mentioned previously, it might be the case that frequency and diversity play different roles at different points in development. The reverse frequency effect in the younger children's performance on the communication verbs can best be explained by differences in diversity. The absence of any frequency effect in the older children's performance might be explained by differences in both diversity and frequency. That is, the older children's productivity with high frequency communication complement-taking verbs is supported by verb frequency and weakened by a somewhat skewed distribution across subject types, whereas their productivity with low frequency communication verbs is weakened by frequency and supported by a more even distribution.

5.3. *Mental-state complement-taking verbs*

In the conditions with mental-state complement-taking verbs, children from neither age group showed any frequency effects. For the mental-state verbs we

found quite entrenched patterns for both high and low frequency items (cf. Table 1). All the mental-state complement-taking verbs we used in the current study are almost exclusively used with either 1SG subjects or 2SG subjects (i.e. *I* or *you*) in German CDS. These high token frequencies and skewed distributions support the development of lexically specific schemas such as *I believe (that)* X or *you mean (that)* X, but they do not support the development of more abstract schemas, such as SUBJ VERB *(that)* X or SUBJ *believes (that)* X. Such abstract schemas can only be developed when children discover formal and functional commonalities between utterances like *I believe* and *he believes*. Utterances like *he believes* or instances of other mental-state verbs used with 3SG subjects, however, are almost absent in the input. Results from the current study suggest that even the older children only have a weak abstract schema of complement-clause constructions and a weak link between item-specific complement-clause constructions with mental-state verbs and 1SG or 2SG pronominal subjects and patterns with mental-state verbs and 3SG subjects.

5.4. *Discourse function and generalization across constructions*

The fact that children had problems in breaking up and changing chunks of complement-taking verbs and 1SG subjects, such as *ich glaube* 'I believe', can also be taken as evidence supporting the claim that items that frequently occur together are processed and represented as one unit (cf. Bannard and Matthews 2008; Pierrehumbert 2001). Moreover, as often seen in processes of grammaticalization (e.g. see papers in Hopper and Traugott 1993), entrenched and routinized linguistic patterns tend to change their meaning. In the case of complement-taking phrases, it has been suggested that subjects and complement-taking verbs that are frequently used together turn into epistemic markers or attention getters (Diessel 2004; Thompson and Mulac 1991). These routinized patterns do not function like main clauses describing mental states with embedded propositions, and they lack strong functional ties to other SUBJ-VP constructions such as the transitive construction and, especially for younger children, even to less frequent complement-taking phrases. In other words, a routinized pattern like *ich glaube X* (I believe X) does not serve the same communicative function as a less frequent exemplar of a complement-taking phrase containing a 3SG subject (e.g. *er glaubt X* 'he believes X') and/or an infrequent verb (e.g. *er vermutet X* 'he presumes X'), and it takes time and opportunity for abstraction and a link between them to get established. For simple transitive verbs, however, it does not matter whether they are used with 1SG, 2SG, 3SG, or PL subjects. Independent of subject types, simple transitive verbs are always used to describe a state of affairs.

That children need more time to develop an abstract representation of complement-clause constructions and a link between different instances of

complement-clause constructions than to develop an abstract representation of simple transitives is indicated by the interaction between age and verb class. The older children showed higher degrees of productivity in all conditions, but particularly in the conditions with complement-clause constructions. This developmental trend cannot be explained by simple frequency alone. Note, for example, that children had less difficulty in changing the subject of the transitive verb *essen* (eat) than changing the subject of the complement-taking verb *glauben* (believe) even though, at least in present tense, *essen* is used less frequently than *glauben* in German CDS. On the other hand, children hear many more simple transitives than complement clauses (cf. Cameron-Faulkner et al. 2003; Stoll et al. 2009), and the transitives they hear also contain a greater variety of subject and verb types, which supports abstraction.

Exactly how many exemplars (individual) children need to hear to form abstract schemas, depending on how skewed the exemplars are, will have to be investigated by controlled training and/or modeling studies. As indicated previously, this might also change throughout development. Younger children might depend on surface similarity or lexical overlap to a higher degree than older children. Further studies will also have to show whether, and if so, when children develop formal and functional links between complement-clause constructions and simple transitive constructions, and how much this depends on (overlapping) subject or verb types. What the current study demonstrates is that frequency is an important factor in language development, but, more importantly, that frequency has many dimensions, and that it interacts with other factors, such as diversity, conceptual complexity, and discourse function.

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Appendix A: Test sentences

TRANSITIVE HIGH FREQUENCY

Essen	*Ich esse Kuchen und Emma schreibt einen Brief.*
'eat'	'I'm eating cake and Emma is writing a letter.'
Malen	*Ich male eine Wiese und Emma gießt Blumen.*
'paint'	'I'm painting a lawn and Emma is watering flowers.'
Trinken	*Ich trinke Kaffee und Emma besucht die Oma.*
'drink'	'I'm drinking coffee and Emma is visiting the grandma.'

TRANSITIVE LOW FREQUENCY

Naschen	*Ich nasche Eis und Emma schreibt viele Bücher.*
'nibble'	'I'm nibbling ice cream and Emma is writing many books.'

Zeichnen	*Ich zeichne einen Baum und Emma holt Saft.*
'draw'	'I'm drawing a tree and Emma is getting juice.'
Schlürfen	*Ich schlürfe Tee und Emma besucht die Tante.*
'slurp'	'I'm slurping tea and Emma is visiting the aunt.'

COMMUNICATION HIGH FREQUENCY

Sagen	*Ich sage, dass Emma gleich zum Zoo geht.*
'say'	'I say that Emma is going to the zoo in a minute.'
Erzählen	*Ich erzähle, dass Emma noch zum Spielplatz fährt.*
'tell'	'I tell that Emma is still going to the playground.'
Hören	*Ich höre, dass Emma gleich einen Kuchen backt.*
'hear'	'I hear that Emma is baking a cake in minute.'

COMMUNICATION LOW FREQUENCY

Singen	*Ich singe, dass Emma noch zum Zirkus geht.*
'sing'	'I sing that Emma is still going to the circus.'
Schreien	*Ich schreie, dass Emma morgen zum See fährt.*
'shout'	'I shout that Emma is going to the lake tomorrow.'
Berichten	*Ich berichte, dass Emma jetzt eine Pizza backt.*
'report'	'I report that Emma is baking a pizza now.'

MENTAL-STATE HIGH FREQUENCY

Glauben	*Ich glaube, dass Emma morgen ein Haus baut.*
'believe'	'I believe that Emma is building a house tomorrow.'
Denken	*Ich denke, dass Emma jetzt einen Ball knetet.*
'think'	'I think that Emma is kneading a ball now.'
Meinen	*Ich meine, dass Emma jetzt einen Hut bastelt.*
'mean'	'I mean that Emma is making a hat now.'

MENTAL-STATE LOW FREQUENCY

Schätzen	*Ich schätze dass Emma jetzt einen Turm baut.*
'guess'	'I guess that Emma is building a tower now.'
Vermuten	*Ich vermute, dass Emma gleich einen Wurm knetet.*
'presume'	'I presume that Emma is kneading a worm in a minute.'
Fürchten	*Ich fürchte, dass Emma gleich einen Schuh bastelt.*
'be afraid'	'I am afraid that Emma is making a shoe in a minute.'

Appendix B: Item effects

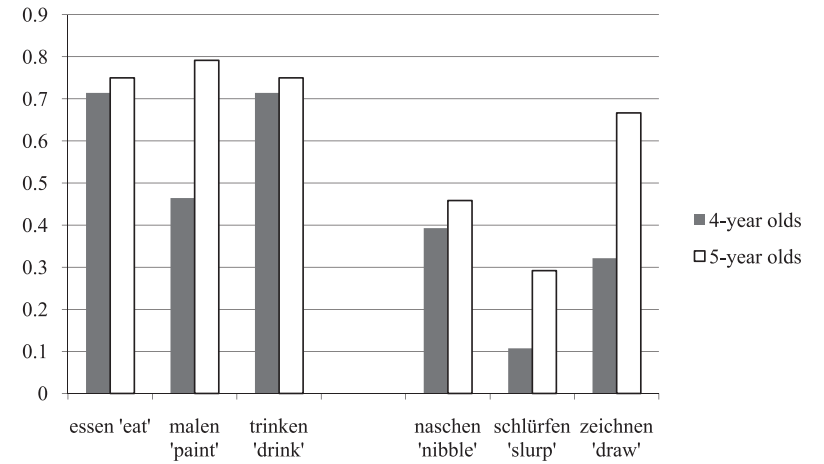

Figure A. *Item effects transitive verbs.*

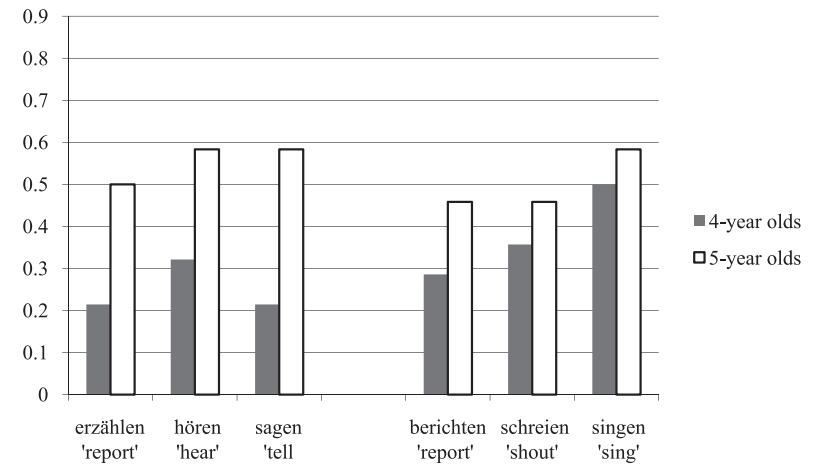

Figure B. *Item effects communication verbs.*

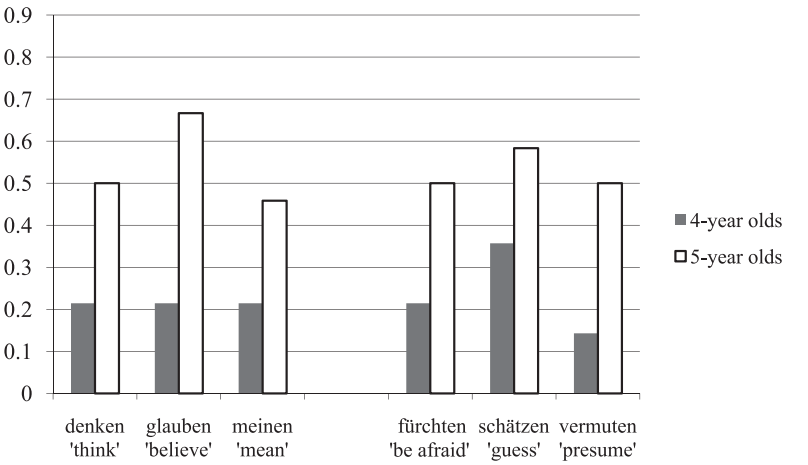

Figure C. *Item effects mental-state verbs.*

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