

Learning to categorize verbs and nouns

Studies on Dutch

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Learning to categorize verbs and nouns

Studies on Dutch

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*“There seems to be a common assumption
that categorization is categorization is categorization.”*
(Mandler, 2000: 6)

At least one thing has become crystal clear to me over the past five years and that is that nothing ‘is’ – in the sense of undeniable and ever-true. And this does not change even if you invest a lot of time and effort in figuring out exactly what the thing is. This is certainly true of categorization, and investigating the acquisition of categories. Although this project was frustrating at many times, I am extremely grateful to the people who helped me in realizing this. Important roles were played in this process by Jan Don and Elma Blom. My thanks and admiration for you is all the greater because of the boundless energy that you give to science. Jan, the time you have invested in this project is unequalled; thank you for all our discussions, which drove me to perform to the extreme. I will always remember your topsport metaphor.

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at once. For example, if an unfamiliar object is named *dack*, we are able to produce and interpret a sentence such as *here are two dacks*. We unconsciously interpret a novel word for an object as a noun and assume that all morphological and syntactic properties that are related to the category noun are applicable to the novel word (e.g., taking the plural marker *-s*, modification by *two*, and functioning as the head of the noun phrase *two dacks*). A similar story holds for novel action words. If an unfamiliar action is named *gorping*, we assume that *to gorp* is a verb and we are able to produce and interpret sentences such as *he gorps* (where the novel word is the head of the verb phrase with *he* as its subject and is marked accordingly with a third person singular *-s*). We use our knowledge of the categories verb and noun to apply all kinds of linguistic properties to new members of these categories. Knowledge of the lexical categories verb and noun seems basic and can be used to determine the combinatorial possibilities of a given new word. Therefore, knowledge of these categories early in the course of acquisition would be helpful for children in categorizing new words in grammatical sentences.

Even though verbal and nominal categories are intuitively straightforward, the precise linguistic details are not so clear. A diverse collection of linguistic properties correlates with these categories but there is no agreement as to which of these properties actually *define* verbs and nouns and which are only *indicative of* verbs and nouns. For a mathematical category such as ‘square’, the defining properties are fairly straightforward: we can categorize a given shape as a square if it has the following three defining properties “A 4-sided regular polygon with all sides equal and all internal angles 90°”. These properties are necessary and sufficient for ‘squarehood’: if a figure has these properties, it is a square; if it does not, it is not a square. Unfortunately the lexical categories verb and noun do not have such necessary and sufficient defining properties that linguists agree upon. This is not to say that adult speakers do not have clear intuitions about verbs and nouns. They can in fact use a number of properties as an indication of which category the word belongs to (e.g., the word’s meaning, the morphemes attached to a word, the position of a word in a sentence). However, this does not mean that these properties define the category. All squares, besides the defining properties, also have other properties that are indicative of ‘squarehood’. For example, they have a measurable surface and they have parallel sides. These properties are applicable to ‘squarehood’, but do not define it, since, for example, there are far more types of objects with measurable surfaces than squares. Such properties that are common to a category, but do not necessarily define them, will be called *indicative properties* from now on. For verbs and nouns there is no agreement on which of the properties that are

indicative of their status are necessary to define them. In Chapter 2 different attempts to define verbs and nouns will be discussed.

For now a number of properties indicative of verbs and nouns will be considered briefly to obtain an idea of the difficulty of understanding their nature. For example, the word forms *apple* and *destroy* display different combinatorial properties at three levels: the sentence, the phrase, and the word. The English form *apple* can be the head of the argument phrase (sentence level, 1a), can be preceded by a determiner (phrase level, 1b), and can be inflected for number (word level, 1c). The form *destroy* cannot be used in any of these combinations, see (2).

- (1) a. I [see [an apple]_{NP}]_{VP}
 b. the / an apple
 c. two apple-s
- (2) a. *I [see [a destroy]_{NP}]_{VP}
 b. *the / *a destroy
 c. *two destroy-s

In turn, *destroy* can be the predicate (3a), can be combined with a subject that determines its form (3b), and can be inflected for tense (3c). These are all combinatorial properties *apple* cannot have, see (4).

- (3) a. I [destroy [furniture]_{NP}]_{VP}
 b. he destroy-s
 c. destroy-ed
- (4) a. *I [apple [furniture]_{NP}]_{VP}
 b. *he apple-s
 c. *apple-d

The morphemes, words, and phrases with which the target words *apple* and *destroy* can be combined are all category-indicative properties. However, they are not necessarily defining properties of the categories verb and noun. Some forms, such as English *walk*, have both the verbal and the nominal combinatorial possibilities mentioned above, see (5).

- (5) a. I had [a nice walk]_{NP}
 b. the walk (in the country)

- c. two walk-s
- d. I [walk [to school]]_{VP}
- e. he walk-s
- f. walk-ed

Depending on the combination in which *walk* is used, it can be interpreted as either a noun or a verb. That the context of a sentence is needed to determine the category of a form is not unusual in English nor in Dutch. But it is extremely common in languages such as Samoan, Tagalog and Mundari (Hengeveld, Rijkhoff, & Siewierska, 2004). For example, in Samoan the form *lā* ‘sun’ (see 6) can be interpreted both as noun (6a) and as verb (6b) depending on the combination of words.

- (6) a. ‘Ua mālosi le lā.
 PERF strong ART sun
 ‘The sun is strong.’
- b. ‘Ua lā le aso.
 PERF sun ART day
 ‘The day is sunny.’
 (Mosel & Hovdhaugen, 1992, ex. (4.44): 80)

Both (6a) and (6b) have the same morpho-syntactic structure: a predicate phrase marked with the perfective marker ‘*ua*, followed by an argument phrase marked with the article *le*. The same word form *lā* can be used both as predicate (6b) and as argument (6a), without any changes in the morpho-syntactic structure of the sentence. The different interpretations of the word form are determined by its position in the sentence structure. This raises the question whether the verbal and nominal properties are connected to the word forms at all. Possibly it is the morpho-syntactic environment in which the form is used that determines the category of the word form.

There are two different views of these uses of word forms in multiple categories. A common morphological analysis of the multi-categoriality of *walk* is that the nominal form *walk* in (5a-c) is derived from the verbal form *walk* in (5d-f) by means of a derivational operation. In the same way, the nominal form *growth* is derived from the verbal form *grow* (7a). The difference between these two derivational operations is that the operation for *grow-growth* is overtly marked with the morpheme *-th*, whereas the *walk-walk* operation is not overtly marked, but has a zero-morpheme $-\emptyset$ in (7b).

- (7) a. grow_V \rightarrow grow-th_N
 b. walk_V \rightarrow $\text{walk-}\emptyset_N$

This latter form of derivation by means of a zero-morpheme is called zero-derivation or conversion (Kiparsky, 1982; Don, 2004). The basic assumption underlying such a derivational analysis is that words are specified for category in the lexicon, for example *apple* is specified as a noun (see Lieber, 1981; Di Sciullo & Williams, 1987; Lieber, 1992). This view of categorization is called lexicalist, because it assumes that category is a lexical property. Since *apple* is a noun, the constituent of which it is the head is a noun phrase.

Several linguists have challenged this lexicalist view of categorization. They propose that categorization is a property of the wider linguistic environment in which a word is used (so *apple* is the head of a nominal phrase because it is inserted in a nominal environment) rather than a property of the word itself (e.g., Hengeveld, 1992b; Goldberg, 1995; Marantz, 1997 - §2.2, §2.4, and §2.5). This second kind of analysis means that Samoan *lā* in (6b) is not the result of a derivational process in the lexicon. It is the syntactic position in the predicate phrase preceded by ‘*ua*’ that marks the item as verbal. On its own, the item is category-less. It is the skeleton of the sentence that is marked for categories, not the word forms that are used in it. Note that the English data in (1)-(4) then need a different explanation; in these theories the ungrammaticality of (4a) cannot simply be attributed to the fact that *apple* is a noun. In fact, Borer (2003) would claim that this sentence is grammatical, but is simply not used in conventional English. A number of linguists with quite different theoretical backgrounds are in agreement on this point, i.e., that category is a property of the morpho-syntactic structure. But the debate has not been resolved.

In sum: verbs and nouns have a number of recognizably different properties that enables language users to categorize them. However, defining verbs and nouns is not straightforward. The study of how children learn to categorize verbs and nouns can help to illuminate the relation between all properties indicative of category and their linguistic definition. In the next section, different facets of how children learn to categorize will be considered.

1.2. Categorization in development

Categorizing linguistic elements is part of the task children face in learning to categorize the world around them. In the literature on general cognitive development, much attention has been paid to the question of how infants learn to

categorize. Mandler (2000) describes the earliest stages of categorization by infants as a joint force of perceptual and conceptual categorization. Children categorize things together if they are perceptually similar. For example, children already categorize different dogs together in one category and different cats in another category when they are 3 months old (Quinn, Eimas, & Rosenkrantz, 1993). The basis of this categorization is the similarity of facial features between all dogs, being distinctively different to the facial features of cats (Quinn & Eimas, 1996). Perceptual categorization allows infants to identify different categories in the world. The identification of category does not automatically provide a meaningful interpretation of that category. Having a perceptual category of all animals with dog-like facial features does not automatically provide the child with information about the nature of dogs. To learn about the nature of dogs, the child needs a conceptual category, a mental representation of the category DOG. Mandler & McDonough (1993) show that infants as young as 9 months categorize animals different from vehicles, even if the exemplars of different categories were perceptually similar. Researchers differ in their opinion about whether perceptual categorization precedes conceptual categorization or vice versa. Mandler (2000) proposes that both processes are at work at the same time. In essence, learning to categorize consists of two different tasks: learning to identify the relevant categories (constructing perceptual categories) and learning to understand the nature of these categories (constructing conceptual categories).

If we assume that these general categorization processes also hold for linguistic categories, children not only have to learn to identify verbs and nouns as different categories (perceive verbs and nouns differently), they also have to learn what verbs and nouns are (use verbs and nouns in an adult-like manner). All linguistic properties that are indicative of category probably trigger categorization in children. Eventually, however, children have to learn which of these indicative properties constitute the defining properties of verbs and nouns to acquire a mental representation of verbs and nouns.

The interplay between cognitive and linguistic categories in the acquisition of word meaning has been the subject of much earlier work on the acquisition of verbs and nouns. Studies on lexical development in a number of different languages such as Hebrew, English, German, Turkish, Japanese, Kaluli, and Mandarin Chinese have shown that the majority of words in early child vocabularies are object words ('nouns') rather than action words ('verbs') (Gentner, 1982; Dromi, 1987; Clark, 1993). This observation has led to a so-called 'noun-verb debate' (Imai, Haryu, Okada, Lianjing, & Shigematsu, 2006), which asks where meaning comes from: whether the conceptual categories underlying word meaning are determined by

general cognition or shaped by linguistic categories (see Bowerman, 2000 for an overview of the discussion on this issue). The outcome of the debate on noun and verb categorization seems to be that the acquisition of verbs (and grammatical words) is predicted to be more prone to language-specific influences than the acquisition of nouns. A number of studies have shown that certain relational and event concepts are indeed influenced by language in the sense that the conceptual categories of speakers differ depending on their first language (e.g., conceptual categories of 'space': Bowerman & Choi, 2001; conceptual categories of 'cutting and breaking': Majid, Staden, Boster, & Bowerman, 2004). The extent to which object concepts are different from these relational and event concepts is a matter of current research (e.g., Malt, Sloman, & Gennari, 2003).

In the noun-verb debate, the category labels verb and noun are roughly used for 'words for actions' and 'words for objects'. However, as already briefly illustrated in §1.1, there are more properties associated with verbs and nouns than just meaning. Furthermore, 'action' or 'object' meaning is not a reliable property for defining the nature of the categories. Not all words that behave as nouns in sentences refer to objects (*pain, crisis* in (8a)) and not all words that behave as verbs refer to actions (*know, love* in (8b)).

- (8) a. I [see [the pain (in your eyes)]_{NP}] _{VP}
 I [see [the crisis (in the world)]_{NP}] _{VP}
- b. I [know [that song]_{NP}] _{VP}
 I [love [that song]_{NP}] _{VP}

That 'having an object meaning' is an indication of nounhood and 'having an action meaning' an indication of verbhood does not mean that object words and action words *are* nouns and verbs. Meaning can be used to identify different categories: a category of action words and a category of object words. However, the ultimate representation of verbs and nouns involves more than just meaning.

The present study will not tackle the subject of linguistic categorization from the perspective of the learning of word meaning. It focuses in the first place on the nature of the *structural* properties of verbs and nouns to inquire how children learn what these categories are. Furthermore, the role of category-indicative properties other than semantics will be studied. The next section specifies the approach taken in this thesis by presenting the research question and the outline of the study.

1.3. Research question and outline of the study

The two kinds of categorization described in the previous section, perceptual and conceptual categorization, serve as the basis for the research strategy used in this study. In order to categorize verbs and nouns, children need to acquire a mental representation of these categories and they need a perceptual trigger to identify the different categories in speech. Both processes take place in the child during acquisition, but not necessarily at the same time and not in the same way. This study focuses on how Dutch children learn to categorize verbs and nouns and thereby aims to provide insight into both the mental representations of verbs and nouns and the process of learning to identify verbs and nouns in the speech stream. The central research question is stated in (9).

(9) When and how do children learn to categorize verbs and nouns?

As will be shown in Chapter 2, different hypotheses exist among linguists as to what the defining properties of verbs and nouns in the mental grammar can be. To decide which theory is most compatible with child language production data, three facts about the theories have to be established. The first is self-evident: for a meaningful comparison of theories, the theories have to have different ideas about verbs and nouns. In Chapter 2, six theories of the representation of verbs and nouns in the mental grammar will be presented and evaluated with respect to their predictions regarding learnability. These theories were selected because they focus on syntactic properties. They come from diverse traditions, namely the generative (Marantz, 1997; Baker, 2003; Borer, 2003), the functional (Hengeveld, 1992b), and the constructionist (Croft, 2000; Goldberg, 2006) tradition. Secondly, it is crucial whether these proposals can be translated into predictions so that their compatibility with child language data can be tested. The gap between a theory of grammatical structure and predictions for the acquisition of this grammar might be difficult to bridge. Therefore, special attention is paid to how the theories can be translated into predictions for child language data. Both the theories and their predictions will be discussed in Chapter 2.

Chapter 3 handles on the third fact to be established, namely whether it is possible to test the predictions on child language data. Since child language utterances do not come with flags on them telling what the structure of the utterance is, we need other methods leading to an interpretation of the data. The decision as to which theory is most compatible with child language data requires appropriate methods for obtaining and interpreting child language data. In Chapter 3 the predictions from the theories will be tested on Dutch children's production data.

Special attention will be paid to the interpretation of longitudinal corpus data. The results of these production studies reveal how Dutch children's representations of verbs and nouns develop over time and what these representations consist of. As will become clear in Chapter 3, the production data show that children apparently have already learned to successfully categorize most of their vocabulary before they produce sentences (sentence production occurs around two years of age). So there seems to be some mechanism available for categorizing at a very young age.

Chapter 4 investigates the category-indicative properties of the input available at an early stage that potentially play a role in the early categorization mechanism operating in Dutch children. The focus will be on the perceptual properties that are phonetically perceivable from the speech stream, namely, phonological properties and distributional co-occurrence patterns. Children are confronted with all the category-indicative properties available in their input. In order to find out whether children are able to detect these indicative properties and use them for categorization, the predictions from one of the input studies in Chapter 4 are tested.

Chapter 5 presents the results of two perception experiments testing the predictions from the input study. The specific property focused on is the frequent co-occurrence of two elements in language, so-called 'frames', that can be used as indicators of the category of the form that falls between these two elements. The use of such frames by Dutch children will be investigated and compared to their use by children from earlier studies of English. The results of these perception studies provide insight into the mechanisms that play a role in identifying categories from the speech stream.

The results of the production studies from Chapter 3, the input studies from Chapter 4, and the perception studies from Chapter 5 together provide a picture of when and how Dutch children learn to categorize verbs and nouns. This picture will be summarized in Chapter 6. The outcomes of this study show that children start learning to categorize verbs and nouns at an early stage of language development and that they use language-specific properties from the input to arrive at these early categories. The discussion in the final chapter will focus on the learning mechanisms used in early categorization and the representation of verbs and nouns in the adult grammar.

2 Linguistic theories and their predictions for category acquisition

Proposals for the defining properties of verbs and nouns in adult grammar should result in learnable representations of these categories and lead to predictions for acquisition. This chapter investigates a number of linguistic theories that are based on different frameworks in terms of whether they meet these preconditions. In order to be able to evaluate each linguistic theory with respect to its compatibility with child language production data, it will be established whether the verbal and nominal representations proposed by the theory can be learned and whether the theory leads to predictions for early language utterances. A third aspect previously mentioned, namely, the testability of resulting predictions, will be addressed in Chapter 3. Whereas the description of the ideas about verb-noun categorization is based on the existing literature on each theory, the description of the predictions is largely based on my own interpretation of this literature.

2.1. Introduction

Verbs and nouns have been central notions in linguistics ever since Plato.² As discussed in the previous chapter, the notions verb and noun involve a considerable number of linguistic properties. The ancient origin of verbs and nouns and their influence on almost every part of the grammar make verbs and nouns basic building blocks of linguistic theory. As a consequence, it is expected that every theory on language has a view as to how verbs and nouns are represented in the adult grammar. This chapter addresses a number of fundamentally different theories and examines their central ideas about verbs and nouns.

The six theories described in this chapter were selected for their common focus on syntactic structure in defining the grammatical properties of verbs and nouns. As already mentioned in Chapter 1, there is a tendency to formulate ideas about verbs and nouns in terms of syntactic rather than lexical properties, and this is true for the many different types of theory. I use the term ‘syntactic’ to indicate the larger sentence context, including ‘constructions’ (Goldberg, 1995). A number of very different theories that play an important role in the field’s present-day discussion of

² Plato introduced the terms *onomata* ‘nouns’ and *rhemata* ‘verbs’ in his *Cratylus*, see Vinokurova (2005: 1-2) for a citation and discussion.

categories all propose a representation of verbhood and nounhood that is formulated at the level of syntactic properties, rather than at the level of the word.

Important differences between the theories relate primarily to the way categories are represented in the adult grammar. They provide different answers to the question of where adult intuitions about categories come from (e.g., the intuition that *apple* is a noun). Some theories posit that these intuitions result from a well-defined mental representation of the categories VERB and NOUN, whereas others hold that these intuitions result from analogical reasoning based on all stored prior experiences with the language, without clearly specified mental representations of verbs and nouns. The syntactic theories of verbs and nouns can be placed on a scale with respect to their assumptions about the mental representation of these categories in adult grammar. At one end of the scale are theories that posit that the categories VERB and NOUN are discrete mentally represented categories. At the other are theories that assume prototype-like mental representations of the categories VERB and NOUN resulting from storage of earlier attested similar word combinations. The discussion of theories in this chapter is more or less ordered according to this representation scale: the proposals with discretely defined grammatical representations are presented first and those assuming more prototype-like representations last. It will become clear that three of the discussed theories propose discrete syntactic categories (Marantz, 1997; Baker, 2003; Borer, 2003), two propose proto-type-like categories (Croft, 2000; Goldberg, 2006), and only one, Hengeveld (1992b), is more or less in between in that he defines discrete syntactic functions, but language-specific lexical classes to express these syntactic functions. The internal ordering of the theories that score similar on the scale is therefore motivated by the predictions they make, as will be shown in §2.6.

The two requirements of covering linguistic facts and the learnability of representations can conflict. To explain all details of a phenomenon a clearly specified mental representation of the category VERB is beneficial, but such a representation would be difficult to learn. Any explanation of the linguistic facts concerning categories must include the notion of learnability (Hornstein & Lightfoot, 1981: 95). The theories reviewed in this chapter deal with this issue in different ways. Some scholars attach more value to accurately covering the linguistic facts, whereas others attach more value to the learnability of the representations proposed by them. In the discussion of their ideas I will first consider how the linguistic facts about verbs and nouns are explained. The central question in this consideration is how the categories are represented in the different grammars. It will also be considered whether, according to the scholars themselves, these proposed representations are learnable.

If theories differ substantially in their underlying tenets, it is expected that they result in different predictions. This then makes it possible to discriminate between them. Otherwise, the theories cannot be tested against one another for their compatibility with child language data. Since child language utterances are often incomplete, we need a method to interpret the data in such a way that the predictions made by the theories can be tested. The present chapter considers the predictions, whereas Chapter 3 tests these predictions. If no clear predictions about a particular theory are available from the literature, I will try to derive predictions on the basis of an interpretation of the theory's tenets.

To sum up, the aim of this chapter is to establish how theories of verbs and nouns differ and which predictions they make for child language production data. This aim will be met by presenting syntactic theories about the categories verb and noun and discussing:

1. Their central idea of how the categories verb and noun are structurally represented in the adult grammar and whether these representations are learnable.
2. Their predictions for the acquisition of verbs and nouns by children.

Sections 2.2 and 2.3 examine the generative theories of Marantz (1997), Borer (2003), and Baker (2003). These theories all propose discretely defined grammatical representations of the categories in adult grammar. The internal ordering in which the discussion of Marantz and Borer precedes that of Baker is arbitrarily chosen and not motivated by the representation scale. Section 2.4 considers Hengeveld's (1992b; Hengeveld & Mackenzie, 2008) functional theory, which in fact also assumes discrete syntactic categories, but posits that the grammatical representations of lexical classes expressing these syntactic functions vary according to language type. Section 2.5 describes the constructionist theories by Croft (1991, 2000) and Goldberg (1995, 2006), which assume only general cognitive representations with prototype-like structure. The description of each theory is followed by a discussion of the predictions for acquisition made by the theory itself or following from a motivated interpretation of the assumptions put forward by the theory. At the end of the chapter a summary will be provided of the theories presented and their predictions for child language data (see §2.6).

2.2. Verbs and nouns as functional syntactic notions

The views advocated by Marantz (1997) and Borer (2003) will be discussed together, since they both consider the syntactic notions of verb and noun as functional notions, existing independently of the lexical items of a language. This

separation of the category information and the lexical items has specific consequences for the predicted path of development, which is similar for both theories.

2.2.1. Marantz (1997) and Borer (2003)

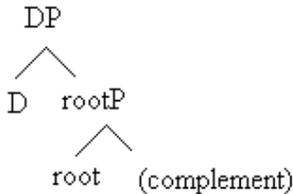
Marantz (1997) specifically tries to account for the linguistic facts alluded to in §1.1: that whereas certain lexical items can be used in nominal syntactic structures (e.g., *apple*, see (1) in Chapter 1), other lexical items can be used in verbal syntactic structures (e.g., *destroy*, see (3) in Chapter 1), and still other lexical items can be used in both (e.g., *walk*, see (5) in Chapter 1). He attributes the information about category not to words in the lexicon but to syntactic nodes in the underlying structure of a sentence. His proposal is in accordance with the Distributional Morphology framework (Halle & Marantz, 1993). Within Distributed Morphology (henceforth: DM), the traditional lexicon as the place where sound and meaning are linked (e.g., Lieber, 1981) does not exist anymore. It has been replaced by a number of lists that contain the atomic elements of a language. The first list contains the elements needed for the syntax to operate on: roots and grammatical features. Crucially, these elements are not listed with a phonological form or meaning. The insertion of a root in syntax precedes the combination of that root with a phonological form and a meaning. Words only exist in a spelled-out syntactic structure, not as autonomous elements. This general architecture of DM has far-reaching consequences for the theory about verbs and nouns. Since words are computed by the syntax, a verbal or nominal category is not a property of a word, but a property of the syntactic structure. Being a verb or a noun has nothing to do with a lexical item. The category status of an item is determined by the functional syntactic structure in which the root is inserted. Verbal and nominal features are given by the syntactic structure and are functional (as opposed to lexical) in nature. Any root that is inserted into a functional syntactic node with verbal properties will be a verb. If the same root is inserted into a functional syntactic node with nominal properties, it will be a noun. The fact that words do not have a special status for Marantz thus has consequences for his central idea of verbs and nouns. The categories verb and noun only exist as features connected to a functional syntactic node.

Borer (2003) has a highly similar approach to the relationship between lexical items and syntactic structure, although the details of her proposal differ from those of Marantz. In both proposals the roots, or items, are underspecified with respect to a number of features, including the category. Categories are provided by the functional syntactic structure and, as such, are actually functional properties. This

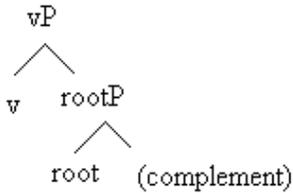
means that to gain a good insight into the central idea of verbs and nouns we have to focus on the specific proposals Marantz and Borer make for the syntactic structures representing the categories verb and noun.

The relevant syntactic structures for the categories noun and verb proposed by Marantz (1997) are the functional heads D (determiner) and v ('LITTLE v': the functional head that projects the external verbal argument). By defining the syntactic structures required for categorization in terms of functional heads and projections, Marantz adopts an extended version of X-bar grammar (Chomsky, 1970). According to Marantz, the difference between the grammatical representations of verbs and nouns is the functional material higher up in the underlying structure. An example of a nominal syntactic structure could be (1), whereas the same structure would be verbal in the case of (2).

(1)



(2)



The functional projection of the syntactic structure in which a root is inserted thus determines the categorization of that root. Roots are atomic elements without a phonological form and with a very general meaning, notated in capitals preceded by the root symbol $\sqrt{\quad}$. An example of an English root that can be inserted in both structure (1) and structure (2) is the root $\sqrt{\text{DESTROY}}$. Remember that this root does not yet have a phonological form, or a specific meaning. The upper case word is just a way to indicate some abstract properties of this root, such as the number of arguments it takes if it is inserted a syntactic environment (see the discussion of roots like $\sqrt{\text{GROW}}$, roots like $\sqrt{\text{DESTROY}}$, and roots like $\sqrt{\text{BREAK}}$ in Marantz,

1997). This root can be inserted into the different syntactic structures. In the case of (1) the root will be merged with the determiner-head, resulting in a noun phrase meaning something like ‘the destruction’. In the case of (2), however, the root will be merged with the verbal head, resulting in a verb phrase meaning ‘to destroy’. How exactly roots are merged with the syntactic structure and receive a phonological form and a meaning is not relevant for this discussion. The main point is that the smallest elements of language are underspecified for category and can, in principle, all be used in both verbal and nominal environments. According to Marantz, the categories verb and noun are represented in the adult grammar as the functional heads *v* and *D* of the syntactic structure.

Borer (2003) defines verbal and nominal syntactic environments in terms of functional structure from a separate functional reservoir with grammatical formatives. The assignment of category information according to Borer works in a similar way as Marantz’s functional structures described above. Although she does not adhere to the DM framework, she also separates the basic elements of language (Encyclopedic Items in her terminology) from the syntactic structure with which they can be merged. The category of the items is determined by the functional formatives with which they are merged in a syntactic utterance. This is comparable to the insertion of a root into a predetermined functional syntactic structure in Marantz’s proposal. In Borer’s model, the grammaticality of phrases is determined by the inventory of phonological forms. If the language has no phonological material to express a certain merger of an item and a functional formative, the utterance is ungrammatical and will not be used by an adult native speaker of that language. In principle, all combinations of encyclopedic items and functional formatives are possible. Just as in Marantz’s view, Borer assumes that every item can, in principle, be used in every category, be it verbal or nominal. Whether the combination of a certain root or encyclopedic item with verbal or nominal structure is grammatical is determined by the availability of a phonological form and a semantic interpretation for the combination in the language.

Both proposals posit that categorization is determined by the functional syntactic structure, but restricted by language-specific word formation processes. The functional syntactic structure that determines verbhood or nounhood is the same for all languages over the world. Verbs and nouns are thus discrete functional categories represented in mental grammar. Since they are universally valid, it is possible to assume that they are innate. What has to be learned, according to Marantz and Borer, is how language-specific lexical items can be used in these pre-given verbal and nominal syntactic structures. Hence, the grammatical structure is supposed to be in place before word learning commences.

2.2.2. Predictions

Although Marantz does not mention any predictions for development, Borer makes a quite specific prediction about how learners map vocabulary items to syntactic structure, and this could in my opinion be extended to Marantz's theory as well. Borer (2004) predicts that the development of vocabulary (i.e., the mapping of phonological forms to meanings) takes place independently of the development of syntactic structure. Since, according to Borer, the inventory of encyclopedic items and the functional lexicon are two independent linguistic constructs, it is not expected that the acquisition of both parts influences each other. Borer (2004) shows that her view predicts a stage in which the syntactic event structures are in place, but the knowledge of vocabulary items is still developing. Using Hebrew child language data, she shows that such a stage is evidenced in argument structure. Hebrew-speaking two-year-olds are able to produce argument structures of different valences (e.g., transitive, intransitive). However, the choice of the specific vocabulary item in Hebrew is dependent upon the syntactic structure. Some items cannot be used grammatically in a transitive structure, although their meaning can be interpreted. Borer shows that Hebrew-speaking children make errors such as (3), in which the child means to say 'I want daddy to feed me now'.³

- (3) ^ʔani roça še-^ʔaba yoxal ^ʔoti řaxřav
 I want that-daddy eat.FUT.3-SG me now
 'I want daddy to eat me now'

(Borer, 2004: 298, example (8) b)

Instead of using the Hebrew vocabulary item for 'eat' (the base form *yxl*) in the correct adult syntactic structure from the causative binyan (*ya^ʔaxil*) 'feed', the child in this example uses this vocabulary item in a simple transitive syntactic structure, saying 'I want daddy to eat me now'. The child has not yet learned that some combinations of stems and syntactic structures render outputs that are non-adult-like. The inventory of phonological forms is not yet adult-like and as a consequence ungrammatical deep-level phrases are allowed to receive a phonological form. If we apply this prediction to the acquisition of categories in Dutch, we would expect a stage in which children have acquired the functional formatives with their categorization features, whereas their vocabulary knowledge is still impaired. Young children in an early stage of language development are predicted to produce errors in

³ I have adjusted the orthography of the example according to the most regular way of notating Hebrew sounds. The ^ʔ symbol represents a glottal stop and the ř symbol a pharyngeal stop.

which stems that can only be merged with a nominal formative in adult language are merged with a verbal one, such as *Mummy trousers me*, reported for English (Clark, 1982: 406).

The predicted pattern of child language data based on these theories for an initial stage in development is characterized by the presence of categorization errors. These categorization errors are interpreted as reflections of mismatches between vocabulary items and syntactic structures that are pre-defined for category. Borer expects that young children's knowledge of vocabulary items is still impaired whereas the functional structure is available to children from birth onwards. As a result, it is likely that children use items in syntactic structures in which they are ungrammatical in the adult grammar. Marantz's and Borer's theories predict that the relevant functional syntactic structures for verbs and nouns are part of the innate grammar. Children have to find out which vocabulary items can be combined with these structures. It is predicted that they make errors in a first stage of vocabulary development, but the syntactic structures are in place, and therefore are already fully developed. However, since this prediction only holds for the first stage of development, it is possible that the children have already passed this stage once they produce sentences. If there are no errors in child production data, this may still be compatible with these theories because the error stage took place at an earlier point in development.

2.3. Universally valid structures for verbs and nouns

Baker (2003) aims to put forward a formal theory of the distinctions among lexical categories that is "adequately grounded in empirical fact" (Baker, 2003: 15). As will be shown in §2.3.1 below, Baker separates the notions of linguistic explanation and learnability. His focus is on the former notion, which has consequences for the nature of the representations proposed and the learnability of these representations. Baker presents his definitions using X-bar theory (Chomsky, 1970). In what follows, his explanation of the linguistic facts concerning verbs and nouns and the learnability of the resulting grammatical representations are discussed and the predictions that can be deduced are evaluated.

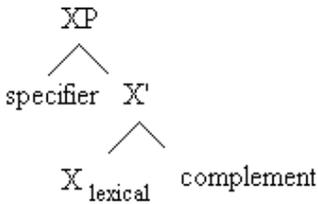
2.3.1. Baker (2003)

Baker (2003) defines the lexical category verb as in (4).

- (4) X is a verb if and only if X is a lexical category and X has a specifier

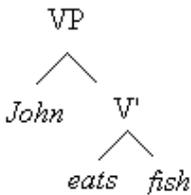
This definition holds that a lexical head (and not a functional head⁴) is a verb if it has a specifier in the phrase of which it is the head, as in (5).

(5)



Defining the distinguishing property of verbs in relation to other lexical categories as “having a specifier” follows from several considerations. A specifier is the syntactic position for the external argument (subject) of a sentence in X-bar theory. According to Baker, what distinguishes verbs from other lexical categories in the syntactic structure is not their ability to have complements (nouns can also take complements, e.g., a prepositional complement as in *a box of chocolates*), but their ability to head a phrase containing both a complement and a specifier as in (6).

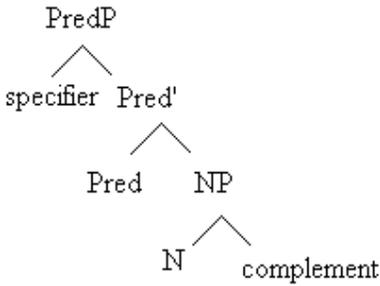
(6)



Verbs can be the predicate of a subject without an extra piece of functional structure, whereas nouns cannot. This implies a difference in the assignment of theta roles between verbs and nouns. Baker suggests that this difference is caused by the presence of a specifier in the underlying syntactic structure. Nouns cannot assign theta roles to the grammatical subject function, but they need an extra (often covert) functional head which Baker calls ‘Pred’; Pred assigns a theta role to the subject of the sentence. The underlying structure of nouns, when used predicatively, is shown in (7).

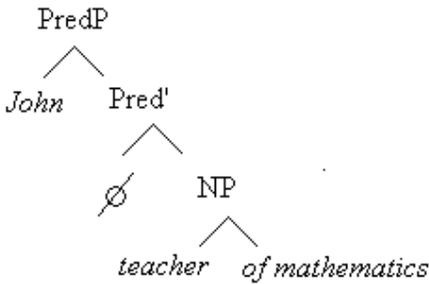
⁴ Most functional heads can have a specifier in their phrase; see the functional head ‘Pred’ in example (7) later on.

(7)



In some languages (e.g., Edo, Chichewa) this functional ‘Pred-head’ is indeed visible in the surface form. Furthermore, Baker shows that previous claims about the differences between verbs and other lexical categories follow directly from the property of having a specifier – namely that these differences are determined by properties such as having tense, or having certain causative morphemes. It is acknowledged in Baker’s proposal that nouns can also have these properties in some languages and certain environments. It is assumed in Baker’s theory that in these cases the PredP contains the specifier, as in (8).

(8)



According to Baker, the universal, distinctive, syntactic property that distinguishes verbs from all other lexical categories is the specifier directly heading the verb in its underlying syntactic structure. This claim is based on several syntactic operations distinguishing verbal and non-verbal structures that can be explained by the presence or absence of a specifier.

Baker presents his definition of nouns in two versions, as in (9).

- (9) a. Semantic version: nouns and only nouns have *criteria of identity*, whereby they can serve as standards of sameness.
 b. Syntactic version: X is a noun if and only if X is a lexical category and X bears a *referential index*.⁵

Both the semantic and the syntactic version provide the same definition of nouns: they can bear a referential index as a result of their logical semantic standard (criterion of identity) by which it can be seen whether the entity designated by the noun is the same as another entity. Baker explains this criterion of identity with the following example (Baker, 2003: 147). Suppose there is a little boy named Nicholas who built a castle from a set of blocks. The building could be described with both sentence (10a) and (10b), and the event could be described with sentence (10c). However, (10d) cannot be inferred from (10a-c).

- (10) a. That is a block set.
 b. That is a castle.
 c. Nicholas made the castle.
 d. *Not*: Nicholas made the block set.

The impossibility of the inference in (10d) follows from the different identity criteria of the castle and the block set; they refer to different identities. Having these ‘criteria of identity’ or ‘referential indices’ makes it possible for nouns to be counted, because only referential concepts can be counted, hence the possibility of numerals or quantifiers with count nouns. According to Baker, nouns can be substituted by pronouns, but verbs not by “pro-verbs”.⁶ This follows from the referential index that is required for a co-reference relationship such as that between nouns and pronouns. Moreover, these referential indices facilitate binding and movement operations where co-indexed traces are required. The assignment of a thematic role also requires a criterion of identity, so nouns are the only lexical category that can be subject or direct object. All these consequences of having referential indices in their underlying syntactic structure are unique properties of nouns, and distinguish them from verbs in every language.

⁵ In Baker’s original definition an addition is made: “... expressed as an ordered pair of integers” (Baker, 2003: 95). Since this paired expression follows from several theoretical considerations that are irrelevant for the purposes of this thesis, I left out this addition and refer the interested reader to Baker’s motivation for these pairs (Baker, 2003: 104).

⁶ Note that the English auxiliary ‘do’ has often been called a “proverb”, as in ‘John hit Harry and so *did* Bill’, but Baker apparently does not adhere to this analysis.

Crucially, the definitions of verbs and nouns presented by Baker follow from the general intuition that verbs are inherently good predicators and nouns are inherently good referrers. The specific part of Baker's proposal is the formalization of these intuitions into details of underlying syntactic structures. Verbs are good predicators because they have a specifier in their syntactic structure, while nouns are good referrers because they have referential indices in their syntactic structure. According to Baker, these detailed syntactic properties of verbs and nouns are represented in the adult grammar.

Whether these grammatical representations are learnable does not seem to interest Baker, as can be deduced from some of his remarks in the final chapter of his book (Baker, 2003: 290-298). He rejects a role for prototypical notional characterizations of verbs and nouns in a grammatical model (see also Newmeyer, 1998). However, he adds that those prototypical notional characterizations are likely to play a role in the categorization of words as verbs and nouns by children. According to Baker, prototypical semantics can play a role in language acquisition, but not in defining the categories of verbs and nouns. Baker makes a sharp distinction between a formal theory of the mental categories VERB and NOUN and learning these categories. With his formal theory of categories he describes how languages organize their content words and explains the differences between categories from differences in underlying syntactic structures. His theory aims to provide an adequate explanation of the *typological* data. However, he does not consider the *learnability* of the grammatical structures proposed by this theory, because he assumes that child language data represent language performance rather than language competence. In his own words:

“That statistical, imperfect, notional characterizations of the lexical categories should play a role in language acquisition (as opposed to grammar) should come as no great surprise, since language acquisition is a messy, statistically driven, heuristic process even for the generative linguist. It is an issue of linguistic performance *par excellence*, not an issue of linguistic competence.” (Baker, 2003: 297)

This quote is followed by his prediction that the earliest words acquired by children are those whose category membership is most consistent across languages (i.e., the most prototypical verbs and nouns). This prediction does not follow from his syntactic definitions of verbs and nouns, but from the process of language acquisition that is, to his opinion, just performance. Baker claims that the meaning of words does not play a role in the definition of verbs and nouns, but can play a role

in their acquisition since this is an issue of performance. Therefore, he predicts that children start categorizing prototypical events and objects, although this behavior has nothing to do with the grammatical representation of verbs and nouns. As Marantz (2003) has remarked, such a strict division between competence and performance has to be criticized. Any theory of linguistic knowledge should involve an account of all language data, including child language data. Baker does not make any attempt to relate his theory to child language data, thereby ignoring learnability as a relevant criterion. Baker presents a more detailed proposal of the defining syntactic properties of verbs and nouns than Marantz and Borer, but does not address how these proposed representations can be learned.

2.3.2. Predictions

As stated earlier, Baker's proposal does not make predictions about how children learn to categorize the words in language acquisition. Nevertheless, it is possible to derive predictions from Baker's syntactic definitions of verbs and nouns. The generative tradition in general makes certain predictions for the path of syntactic development, and since Baker works in this tradition, we can apply this line of reasoning to the acquisition of his underlying syntactic structures defining verbs and nouns.

As shown with respect to the proposals by Marantz and Borer in §2.2, it is plausible to assume the grammatical representations of verbs and nouns to be innate if they are universally valid. Baker proposes that the categories verb and noun are indeed universal. It may therefore be assumed that the structures he proposes for verbs and nouns are part of an innate Universal Grammar. As a consequence, children never have a grammar in which the structure for verbs and nouns is qualitatively different from the universal structures. The subsequent prediction is that children have to learn which words belong to which lexical category.

The predicted pattern of child language utterances based on my interpretation of Baker's theory is that children assign content words to either the verbal or nominal category from an early age onwards and use these words accordingly. Since the central syntactic property of verbs is predication and the central property of nouns is reference, it is predicted that if children use verbs, they use them predicatively and if they use nouns, they use them referentially at an early stage of language development. After all, the predicative use of nouns requires more functional structure and is thus more marked than the referential use of nouns. Once the child encounters enough evidence for the predicative use of nouns, she should retreat from this strict division and gradually use more nominal words in a predicative structure with an underlying predicative functional head.

2.4. Possible classes of verbs and nouns based on typology

Hengeveld (1992b) proposes a typological theory of verbs and nouns, among other ‘parts of speech’, from a different theoretical perspective, but with a similar approach to the relevance of syntactic properties in category assignment. This proposal takes the perspective of Functional (Discourse) Grammar (Dik, 1997; Hengeveld & Mackenzie, 2008). Hengeveld distinguishes the notion of ‘lexeme’ from the notion of ‘syntactic function’. The categories of verbs and nouns in a certain language can be defined by investigating the possible links between verbal and nominal lexemes and their syntactic possibilities. This separation of lexemes and syntactic functions is comparable to the separation of roots (§2.2.1, Marantz, 1997) or encyclopedic items (§2.2.1, Borer, 2003) from syntactic structure. However, an important difference between this theory and the previously discussed theories is that a certain class of lexemes may be used in more than one syntactic function (predication or reference), which means not all languages need to have the same number of categories.

2.4.1. Hengeveld (1992)

Hengeveld (1992a, 1992b) distinguishes four functions in a sentence that can be expressed with content words. The function of a word in a sentence is determined by its function in a syntactic phrase. The four functions in a sentence are divided over two different types of syntactic phrases: the predicate phrase and the referential phrase (i.e., the ‘argument phrase’), comparable to the Verb Phrase and the Noun Phrase of generative grammar, respectively.⁷ The main difference is that, by using the terminology ‘predicate’ and ‘referential’, Hengeveld allows different possible heads of phrases. This is relevant because Hengeveld emphasizes the importance of separating syntactic phrases from the lexemes that can express them. Within these phrases, lexemes can function either as the head of the phrase or as a modifier in the phrase. This results in the following four possible syntactic functions that can be expressed in a sentence:

- Head of a Predicate phrase (henceforth HP)
- Head of a Referential phrase (henceforth HR)
- Modifier in a Referential phrase (henceforth MR)

⁷ Hengeveld and Mackenzie (2008) make the same distinction in syntactic phrases as Hengeveld (1992), but their terminology differs, as the predicate phrase is called ‘ascriptive subact’ and the referential phrase is called ‘referential subact’. Here, I will use the terminology from Hengeveld’s earlier work, as the distinction remains the same.

- Modifier in a Predicate phrase (henceforth MP)

These functions are illustrated in (11) for English.

Classes of lexemes can lexically express one or more of these syntactic functions. Languages differ from each other in the number of content word classes they have. Multiple syntactic functions can be expressed by a single word class in a language, so there need not be as many word classes as there are syntactic functions to be expressed. English has four content word classes, each of which can be used in one of the four syntactic functions, as shown in example (11), taken from Hengeveld (1992b: 37, function indications added, ME).

(11) [The [nice]_{MR} [president]_{HR}]_{Referential phrase} [[sings]_{HP} [well]_{MP}]_{Predicate phrase}

However, a lexeme such as *president* can also be used in HP and MR, as shown in examples (12) and (13), both taken from Hengeveld (1992b: 37, function indications added, ME).

(12) [John]_{HR, Ref. phrase} [is [president]_{HP}]_{Pred. phrase}

(13) [John]_{HR, Ref. phrase} [has [a [presidential]_{MR} [style]_{HR}]_{HP, Ref. phrase}]_{Pred. phrase}

The crucial difference between these two examples is that in (13), the lexeme *presidential* is a derived form, construed by the addition of the derivational morpheme *-ial*. Such derivational morphology falls under Hengeveld's umbrella term 'further measures' and results in a different lexeme. It is not the lexeme *president* that is used in MR in (13) but the lexeme *presidential*. The lexeme *presidential* belongs to the class of adjectives in English. Although the copula *is* in (12) also falls under 'further measure', the lexeme *president* itself does not change. Based on these observations, Hengeveld defines verbs in English as lexemes that can only be used as the head of a predicative phrase, whereas nouns are lexemes that have the unique possibility of being used as the head of a referential phrase. Nouns may also have other possible uses in a language, such as the predicative use in English. Note that Hengeveld's analysis of nouns functioning as the heads of predicative phrases differs principally from Baker's analysis (§2.3.1), according to which nouns never function as a predicative heads. Baker assumes an empty functional predicating head, whereas Hengeveld assumes that the noun itself is the head of the predicate phrase.

In sum, the crucial notions for distinguishing lexeme classes as verbs and nouns in Hengeveld's theory are their different possibilities to fulfill syntactic functions. Whereas verbs are lexemes that can only function as the head of the predicate

phrase, nouns are lexemes that are able to function as the head of a referential phrase (and possibly have additional functions depending on the language). Here, Hengeveld's proposal differs from the proposals discussed in previous sections since these proposals define specific distinct structures for verbs and nouns. Hengeveld only defines syntactic functions; the possibility for verbs and nouns to fulfill these syntactic functions differ per language. According to Hengeveld, the representations of the categories VERB and NOUN in the adult grammar thus consist of the language-specific mappings of lexemes to the syntactic functions HP, HR, MR, and MP.

The learnability of these representations depends upon the learnability of the syntactic functions HP, HR, MR, and MP. Since the language-specific properties of verbs and nouns are defined by the ability of lexeme classes to express these syntactic functions, the availability of the syntactic functions seems a prerequisite for acquiring the categories verb and noun. It is not clear from Hengeveld's proposal whether these syntactic functions are learned or pre-given, but since they are universally valid, it is plausible to assume that they are innate.

2.4.2. Predictions

Hengeveld does not explicitly predict child language patterns that follow from his theory. However, he formulates predictions for typological patterns, from which predictions for child language can be deduced. Berwick (1985) proposed that there is a relationship between typological patterns and child language acquisition that is characterized by the Subset Principle. If there is an implicational relationship between different types of languages, children will start with the most minimal option, that is, the option present in all types of languages. According to Hengeveld (1992b; repeated in Hengeveld & Mackenzie, 2008), the way in which languages divide their lexemes into word classes with distinct syntactic possibilities indeed displays an implicational relationship. Languages that do not have four different classes of content words, but instead have one, two, or three, seem to combine syntactic functions in a fairly systematic manner. Hengeveld investigated a sample of 50 languages for the kind of syntactic functions they express with distinct content word classes. This typological study led Hengeveld to propose the hierarchy of syntactic functions with respect to word classes presented in (14).

$$(14) \text{ HP} < \text{HR} < \text{MR} < \text{MP}$$

This hierarchy indicates that the further to the right a syntactic function is situated, the more likely it is that a language does not have a separate class of content words

that expresses only this syntactic function. That is, if a language combines the expression of two syntactic functions in one word class, it is most likely to combine the MR and the MP. In its strongest form⁸, this hierarchy states that the implication of having a separate class of content words to express the MR is to have content word classes that typically express the HR and the HP, since they are further to the left in the hierarchy. Hengeveld based this hierarchy on what he found in his sample of languages, and predicts that this implicational hierarchy will hold for languages across the world. The largest group of languages in the sample (20 out of 50) expresses all four syntactic functions with a separate word class. Two languages have only one word class, 10 languages have two word classes, and 18 languages have three word classes. If a language did not have a separate word class to express the HR, it also did not have separate word classes for MR and MP. For typology, the prediction is thus that the hierarchy of syntactic functions determines the number and nature of possible word classes in languages. Applying this prediction to language acquisition, we can predict that the hierarchy of syntactic functions determines the word classes used at different stages of acquisition, starting with the minimal option (i.e., the leftmost one). Thus, children should learn to use lexical words to express these syntactic functions from left to right in the hierarchy.

If the prediction that the hierarchy of syntactic functions determines the use of lexical words by language-learning children is borne out, specific child language patterns should be observed. Since children need to find out how many different word classes their mother tongue has to express the different syntactic functions, they may start by using the lexemes of their language only to express the HP. This means they use content words only predicatively in the first stage of language development. Since all word classes can be used predicatively in the languages investigated by Hengeveld, such a development would not result in ungrammatical utterances. The child language production pattern therefore does not differ qualitatively from the adult pattern, but the prediction is that children use relatively fewer content words in HR (as a percentage of their total content word production) than adults. If children receive evidence from the input that a specific class of words is used as the head of referential phrases, they may expand their pattern accordingly. It is predicted that the child will not use content words referentially until she receives enough evidence from the input to do so. Depending on the language learned, this expansion process continues with the modifying functions until the

⁸ Recently, weaker versions of this hierarchy have been proposed (Hengeveld & Van Lier, 2008), in which the hierarchy is an interacting system of two different implications rather than a true implicational hierarchy. However, Hengeveld & Mackenzie (2008: 227) still use a strict implicational interpretation. This implicational interpretation is used here, because it leads to clear predictions.

child uses the all word classes distinguished in her first language in the appropriate functions. A child learning a language with a single word class has an easier job than a child learning a language with four different word classes for the different syntactic functions. In all cases, the child language data will not show errors, since the input drives the expansion of the number of word classes. However, quantitative differences are expected between the proportions of words used by adults and children across syntactic functions. Some patterns are clearly not predicted based on Hengeveld's typological hierarchy. Since all languages in the world that express the MP with a separate word class also express the three other syntactic functions with a separate word class, children should not start using all their early content words as MPs only. To put it even more strongly, children should not use single lexical items to express any of the syntactic functions HR, MR, and MP before they use them to express HP.

The crucial part in the acquisition of verbs and nouns according to Hengeveld is not the acquisition of the syntactic functions represented in the grammar, but the expression of these syntactic functions with lexical items. The prediction is that children will obey the implicational hierarchy of syntactic functions and consequently start using words predicatively, gradually expanding the use of certain word classes to the other three functions in the predicted order. The prediction for child production data is that children do not make errors, but their production patterns in initial developmental stages is quantitatively different from that of adults.

2.5. Verbs and nouns emerging from constructions

Both Croft (1991, 2000, 2001) and Goldberg (1995, 2006) present constructionist approaches to language, defining grammatical constructions as "conventionalized pairings of form and function" (Goldberg, 2006: 3). These authors define a grammar as a collection of constructions that differ in size and in abstractness. This collection emerges in the mind as a result of general human cognitive abilities such as memory, learning, and attention. The resulting representations are therefore always the result of surface generalizations, i.e., generalizations over the language actually used by speakers. These proposals focus more on learnability than on covering all linguistic facts connected to verbs and nouns, although of course an attempt is made to also do the latter. The representations assumed by constructionists can differ across language users and can have a prototype-like structure.

2.5.1. Croft (1991) and Goldberg (1995)

Croft's (1991) proposal does not define verbs and nouns in terms of structural properties, although this was the criterion for the selection of theories in this chapter. Following a cognitive approach to grammar (Langacker, 1987), he starts his theory of verbs and nouns with the conceptualizations people have about the world. This approach is thus actually not a syntactic or distributional approach in the strict sense, but it ultimately does refer to distributional characteristics for the grammatical representations of verb and noun. The relevant conceptualizations for these categories are predication (i.e., making an "entity into a transitory state of affairs" (Croft, 1991: 108)) and reference (i.e., creating "an autonomous entity and making it into a kind or individual of the kind" (Croft, 1991: 108)). According to Croft, these conceptualizations are the basic pragmatic functions that determine language use. These pragmatic functions can be expressed by different words belonging to different word classes across different languages. However, certain words in language are prototypically used for predication, whereas other words are prototypically used for reference. These prototypical uses seem to be universal across languages and are called verbs and nouns by linguists. Croft (2000: 88) proposes typological prototypes for the categories of verbs and nouns as shown in (15).

(15) Verb	=	predication of an action
Noun	=	reference to an object

These prototypes are the most unmarked combinations of the meanings, the pragmatic functions and the word classes available in a language. The combinations presented in (15) are prototypes in the sense that they reflect the least marked functions of verbs and nouns; they are not the only functions possible. These prototypical conceptual categories are mentally represented. In Croft's proposal, the prototypical categories are universals, but the boundaries of these categories differ across languages. Boundaries can be sharp or fuzzier to different degrees, depending on the language. It is crucial that the determining factor for categorization in a language is the mapping of words to a concepts that are also used for other purposes than language, for example for the perception of events. There are no categories that are specific to language. The categorization of a language-specific group of words depends upon generalization over the distribution of words in the constructions of the language under consideration. So although Croft's central idea of word classes is not syntactic or distributional per se, the emergence of categories is based upon the language-specific distribution of certain constructions.

Goldberg (1995, 2006) proposes an architecture of speakers' knowledge of language similar to that of Croft. According to Construction Grammar, linguistic representation in the mental grammar consists of systematic collections of constructions that are stored based on perceived speech. Constructions are pairings of form and function in different possible sizes: words, morphemes, idioms, and argument structures are all considered to be constructions. As a consequence, words do not have a special status compared to morphemes, phrases, or sentences. In this respect Goldberg's idea is in agreement with the proposals by Marantz and Borer discussed in §2.2: a principled distinction between morphological and syntactic processes is not made. The major difference from the proposals discussed earlier is, however, that Goldberg places all constructions (from morphemes to sentences) in the lexicon, whereas Marantz and Borer eliminate the lexicon by proposing that linguistic units of all sizes are computed in the syntax. An important consequence of the lexical nature of constructions in Goldberg's view is that constructions cannot be separated from their meaning or function.

In her proposal about how argument structure is represented in grammar, Goldberg (1995) emphasizes the important role of the inherent semantics of argument structure constructions. The meaning of a given sentence is not determined by the meaning of all individual lexical items that form that sentence, but by the meaning of the 'argument structure construction' used in the sentence. In the argument structure constructions, variables are defined for the arguments of the sentence. For example, the argument structure construction of the ditransitive is defined as in (16).

(16) X CAUSES Y to RECEIVE Z

In English, X and Y are often expressed with animate referring object words ('animate nouns'), Z is often expressed with an inanimate referring object word ('inanimate noun') whereas CAUSES to RECEIVE is often expressed with a ditransitive predicating action word ('ditransitive verb'). A prototypical example of a construction based on this argument structure construction is presented in (17).

(17) John gives Bill a book

However, since the argument structure construction itself has a meaning, speakers can interpret sentences like (18a) and (18b), eventhough *bake* is generally not considered to be ditransitive, *book* is not an animate noun, and *a lot to think about* is not an inanimate noun.

- (18) a. John baked Bill a cake
 b. The book gave John a lot to think about

Conversely, the linguistic possibilities of the different elements of the constructions in (17) and (18) such as *John, Bill, book, cake, gives, baked, and gave* are determined not only by the properties of the elements themselves, but for a large part by the properties of the constructions in which they are used.

Categories, according to Goldberg, emerge in the lexicon (Construction Grammar does not distinguish lexicon from grammar) when constructions share the same distribution. This means that constructions of all possible sizes can be categorized together if they often share the same distribution. The linguistic forms that most frequently express variable X in (16) result in a prototype category that is the kernel of a wide network of associations, including other kernels. For example, the prototypical category consists of strong associations between the ‘animate noun’ constructions *John, Bill, Mary, he, she, the waitress*, etc. Another prototypical category consists of strong associations between the ‘inanimate count noun’ constructions *the book, apples, the cup*, etc. This second kernel, in turn, can be in the associative network of the first, so that the networks overlap. These combinations of kernels that are at play across more than one network gradually form larger categories. Goldberg focuses on the smaller networks by describing different categories of verbs based on the different constructions they can appear in (e.g., transitive verbs, intransitive verbs, and ditransitive verbs) and not so much on a larger, generalized class of verbs. Similarly for nouns, words are categorized differently as mass or count nouns based on the different constructions they can appear in. The larger categories VERB and NOUN are represented in the adult mental lexicon by an associative network of different kernels of strongly associated exemplars that frequently occur in similar constructions.

The central idea put forward by Croft and Goldberg emphasizes the emergent and language-specific character of categories such as verbs and nouns. Only those words that frequently share the same distributions in constructions of a language are actually categorized together by language users based on surface-level generalizations. In the adult grammar, verbal and nominal categories are represented as collections of items that very frequently occur in similar constructions. Items that share many distributional contexts are the most prototypical verbs and nouns, i.e., the predicating action words and the referring object words. The representations of verbs and nouns consequently differ across languages and across speakers. After all, not every speaker encounters the same constructions in the same frequency. The

representation of verbs and nouns emerges as a result of learning. As a consequence, the proposed verbal and nominal representations are inherently learnable. The surface language determines the representations, which emerge in the mental grammar as a result of the input. If there were no input language, there would be no verbal and nominal representations. The innate knowledge is restricted to general cognitive knowledge such as the ability to recognize patterns and the ability to make analogies. No knowledge specific to language is available for the child before she encounters input.

2.5.2. Predictions

Since these constructionist theories interpret the classes of verbs and nouns as emerging from the distribution of constructions in a language, the predictions for child language development can be drawn directly from the development of categories in general. Since category emergence in general is described as a gradual process, the prediction is that category development also takes place gradually, reflected in different developmental stages of child language production. Categories are generalized patterns of the constructions in which certain types of words can occur. To acquire verbal and nominal categories, children attend to the input language they hear and use their general cognitive abilities to make surface-level generalizations from these input utterances. The results of this process are the end-state categories as assumed by constructionists, i.e., prototype-like representations in an associative network. Different developmental stages will be reflections of different cognitive stages combined with the language input received. The first sentences produced by children will be imitations of (parts of) earlier perceived sentences in the input. If the exposure to sentences with the same structure passes a certain threshold, children will break up the sentence level construction into smaller parts and produce more creative language utterances (Tomasello, 2003). The predicted pattern of child language based on these constructionist theories is different for different stages of development. The first stage of development should be marked by distributional patterns that can literally be traced back to adult input sentences. Such trace-back analyses have been performed for other aspects of grammar acquisition (Lieven, Behrens, Speares, & Tomasello, 2003). After a certain amount of exposure, child language patterns become more creative, in the sense that parts of previously heard constructions are interchanged. At still later stages, the associative networks have grown so strong that they can produce new constructions, so more creativity beyond the adult input is expected. However, children at the earliest, pre-generalization stage of language development are predicted not to use items, constructions, and sentences in ways that are unattested in adult language.

2.6. Summary and conclusions

The aim of this chapter was to provide an overview of fundamentally different linguistic theories, presenting their central ideas on how the categories verb and noun are represented in adult grammar and the predictions they make concerning acquisition. In this final section, I will first summarize the findings of the previous sections for a concise overview of all theories discussed in relation to child language data. From this summary it should become clear to what extent the theories make different predictions for acquisition and whether they are distinguishable from each other on the basis of these predictions.

For each of the six theories discussed in this chapter we have seen what their central idea of verbs and nouns is. The theories first discussed propose discrete universal grammatical representations of verbs and nouns, whereas the theories discussed last propose prototype-like and speaker-dependent grammatical representations of these categories. The theories that assume discrete representations in general provide a more precise definition of verbs and nouns than those that assume prototype-like representations. Marantz (1997), Borer (2003), and Baker (2003) define specific syntactic structures determining verbhood and nounhood. Hengeveld (1992b) also defines specific syntactic functions relevant for categories, but adds to this a proposal for the definitions of lexical classes of verbs and nouns that differ across languages. These lexical categories namely depend on the language-specific expression of these functions. The constructionist theories (Croft, 1991; Goldberg, 1995; Croft, 2000; Goldberg, 2006) propose a more prototype-like representation of verbs and nouns that differs across languages and speakers.

At the end of each subsection on these central ideas, I briefly discussed the extent to which the proposals include learnability considerations. That is, whether the proposed representations can be learned or can be assumed to be part of an innate grammar. Learnability is in fact the most important aim of the constructionist theories. Their proposals for how verbs and nouns are represented in the adult grammar are actually based on the representations that emerge during learning. These representations are inherently learnable. There seems to be a correlation between the way (presence or absence) a theory incorporates linguistic facts and learnability and the position the theory has on the 'representation scale'. The primary aim of theories proposing detailed universal grammatical representations is to account for all linguistic facts concerning these categories. As was shown for Baker (2003), this is even his only concern, as learnability considerations are not included in his proposal. Generally speaking, if a theory focuses more on the

numerous linguistic facts about verbs and nouns, it proposes a more abstract grammatical representation of discrete verbal and nominal categories; if a theory focuses more on the learnability of verbs and nouns, it proposes a fuzzier representation of prototype-like verbal and nominal categories.

For us to be able to compare the compatibility of the theories with child language data, the theories have to make different predictions. Most of the theories do not in themselves make explicit predictions for child language acquisition, except for Borer's (2004). However, on the basis of their tenets, I could derive some predictions for all theories. The theories of Marantz (1997) and Borer (2003) predict categorization errors during early development, because children have to find out which vocabulary items can be used in the pre-given verbal and nominal syntactic structures. It is predicted that children use items in category structures that are nonexistent from an adult point of view at an early stage of development. Although it is hard to translate Baker's ideas into predictions, my own interpretation predicts a very conservative use of verbs and nouns as predicators and referrers in an early stage of development. The prediction from Hengeveld's implicational hierarchy of language types is also conservative: in accordance with the hierarchy for language types, children probably start with the assumption that lexical items can be used predicatively. Based on evidence from the input, a subset of vocabulary items can be used for reference. The difference between the predictions based on Baker and Hengeveld's proposals is that Hengeveld would expect that children at a very early stage of development do not yet have a class of words reserved for reference. The relative proportions of content words used across syntactic functions is expected to differ quantitatively from the proportions of adults. However, they should not make errors. Croft (1991) and Goldberg (1995; 2006) propose that categories emerge from surface level language use. Categories therefore should emerge in child grammars during development, based on the input language children attend to. They gradually make generalizations of the constructional patterns. As a consequence, at an early stage of development children are expected to use verbs and nouns correctly in those constructions that are attested in their input.

In sum, the six theories for child language production patterns can be reduced to only two qualitatively different predictions, as can be seen from Table 2.1. Most theories predict an initial stage of very conservative, adult-like use of verbs and nouns by children. Hengeveld allows for the possibility that children are even more conservative than adults, as should be evidenced by a stage in which they only use words predicatively. Only Borer strongly predicts an initial stage of categorization errors, a prediction that can also be applied to Marantz's proposal. Adult-like production patterns (i.e., no errors) are compatible with four out of the six theories.

Table 2.1. Summary of the six syntactic theories of verbs and nouns and their predictions for the earliest child production data (ordered according to the presentation in this chapter).

<i>Theory</i>	<i>Central idea of verb and noun</i>	<i>Predictions for initial child language production</i>
Marantz (1997)	Insertion of atomic roots and phonological forms in syntactic structures with functional heads D or v	Categorization errors are predicted
Borer (2003)	Merger of functional formatives specified for nominal and verbal features with encyclopedic items.	
Baker (2003)	Lexical heads with either a specifier (verb) or referential index (noun) in underlying syntactic structure.	Adult-like use of words in syntactic patterns predicted
Hengeveld (1992)	Lexical items that can either occupy the head of predicate phrase (verb) or the head of referential phrase (noun).	Adult-like (but possibly quantitatively different) use of words across syntactic patterns predicted
Croft (2000)	Language-specific distributional patterns make different categories emerge from constructions with predicating and referring elements.	Adult-like use of words in syntactic patterns predicted
Goldberg (2006)	Surface-level generalizations of overlapping construction parts, resulting in several smaller distributional categories.	

Thus, although the ideas about verbs and nouns presented by Baker (2003) and Goldberg (2006) are fundamentally different in nature, they cannot be distinguished from each other by evidence from child language production data. Whereas Baker has a detailed view of how discrete verbal and nominal categories are anchored in the language competence, Goldberg sees categories as associative networks emergent from language use itself. Ideally, it would be possible to evaluate the extent to which these different ideas yield the most appropriate account of the representations of verbs and nouns in adult mental grammars. Since the appropriateness of an idea depends, among other things, on learnability, one possible evaluation procedure is to test the compatibility of the ideas with child language

data. However, with respect to the acquisition of the categories verb and noun, both theories predict adult-like production patterns in early child language.

The two proposals that define the categories verb and noun in the functional syntactic structure by Marantz and Borer do not predict adult-like production patterns from the start. As Borer (2004) spells out, it is strongly predicted that children pass through a stage in which they have acquired the syntactic categories, but have not yet acquired the correct mappings of lexical items to these syntactic positions. As a consequence, they will make categorization errors of the sort *Mummy trousers me*. Although this prediction is different from the other predictions, adult-like production patterns are even consistent with these theories. If the error stage takes place before children produce multi-word utterances, there is no way to distinguish these theories from all other theories of this chapter. This is, however, a methodological problem, which I will address in Chapter 3.

Concluding this chapter on the ideas and predictions about verbs and nouns made by different theories, four of the theories discussed can only be compared on their compatibility with child language data if it can be determined that the child language patterns deviate qualitatively from the adult-like patterns proposed by these theories. If categorization errors are found in very early child language patterns, there is some evidence for the other two theories by Marantz and Borer. However, in later production stages errors are also predicted by the constructionist theories. What needs to be established in Chapter 3 is which prediction is borne out by the data. The focus of Chapter 3 is on Dutch children's production data, which will be studied by means of an analysis of a spontaneous speech corpus.

3 Production studies of categorization by Dutch children

This chapter reports two studies that test the predictions from Chapter 2 on child language production data. The learnability of the verbal and nominal representations proposed are pivotal for a viable theory. The theories make two different general predictions for child language production data: either children make a considerable number of categorization errors, or they show adult-like production patterns from the start. In this chapter the predictions are tested by studying Dutch children's production data. The methods used to analyze these production data will be evaluated with respect to their efficacy in testing the predictions from Chapter 2, and conclusions will be drawn on the basis of the results with respect to the compatibility of the theories with these data.

3.1. Introduction

In the studies presented in this chapter the focus will be on child language production data. The predictions from Chapter 2 will be investigated to decide which theory is most compatible with such data. From the theories in Marantz (1997) and Borer (2003), it is expected that children will make categorization errors at an early stage of language production because their vocabulary development lags behind their syntactic abilities (see §2.2). To test this prediction a small study of categorization errors in Dutch children's spontaneous speech was conducted and is reported in §3.2.

The other theories described in Chapter 2 all predict that children will show an adult-like use of words in syntactic patterns. Baker (2003) assumes that the categories verb and noun are innate and according to my interpretation of this assumption (§2.3.2), children therefore immediately categorize words as verbs or nouns. Hengeveld (1992b) predicts that children are adult-like, or even more conservative than adults, in their use of verbs and nouns, because they follow the implicational hierarchy. This prediction implies that children start from the assumption that there is only a single class of content words for predication and only gradually expand this assumption towards a word class for reference. Croft (1991, 2000) and Goldberg (1995, 2006) assume that children build their categories gradually based on the input language, and as a consequence restrict themselves to the adult pattern at an early stage of language production. To test the prediction that

children will show adult-like categorization patterns at an early stage of production, a larger study was conducted that took all content words into account, instead of only the possible errors. This longitudinal corpus study conducted on Dutch children's spontaneous speech is presented in §3.3.

The outcomes of the studies suggest that Dutch children hardly make any errors, instead showing an adult-like pattern from early on. Based on these outcomes, §3.4 discusses the success of the research strategy using early production. Another research strategy is presented that potentially provides more insight into the process of learning to categorize verbs and nouns in Dutch.

3.2. Categorization errors in Dutch children's spontaneous speech

The analysis of the errors children make in their spontaneous speech production is a common method of investigating grammatical development (e.g., Bowerman, 1974; 1976). For example, in morphological development the overgeneralization of the regular past tense form, as in *I eated an apple*, has often been studied (Marcus et al., 1992; Maratsos, 2000; Maslen, Theakston, Lieven, & Tomasello, 2004). These overgeneralization errors are indicative of the grammatical representation of past tense in the child's grammar; the child's grammar contains a rule for past tense inflection.⁹ The points where the child diverges from the adult patterns and produces non-adult-like language can be observed. In the process of learning to categorize, children are expected to make errors in categorization that reveal the underlying structure of their early categories with respect to those of adults, at least to some extent. Marantz and Borer explicitly predict categorization errors. The study reported here tests this prediction against Dutch children's spontaneous speech production. However, there are many methodological problems in identifying and interpreting categorization errors. These difficulties will first be discussed in general and will then be taken into account in the analysis of this study.

3.2.1. Interpreting categorization errors

A categorization error is attested once a child uses a word form with the morpho-syntactic properties of a category in which it cannot be used in adult language, just as a morphological error is attested once a child uses the irregular verb *eat* with a regular past tense inflection. However, recognizing a categorization error is more

⁹ Although not all scholars agree on the fact that the mental grammar contains rules (see discussion in e.g., Rumelhart & McClelland, 1994; Pinker, 2001), there is at least some kind of abstraction for past tense in the child's grammar.

difficult than recognizing a morphological error. The regular past tense inflection in English always has the surface form *-ed*. Furthermore, expressing the regular past tense is one of the few functions of the morpheme *-ed* in English. This means that once an *-ed* ending is attested on a form that cannot have this ending, it can be identified as a morphological error of past tense inflection. For categorization errors, there is no such one-to-one relationship between a morpheme and a category. Although verbs often take tense inflection and nouns often take number inflection, this is not necessarily the case (e.g., irregular verbs like ‘know’, ‘leave’, or ‘buy’ do not take *-ed* in the past tense; mass nouns like ‘sand’, ‘water’, or ‘mud’ are usually not inflected for number). Furthermore, all properties that are indicative of category membership have some other function as well; although tense inflection is indicative of verthood, the main function of a tense morpheme is to express tense, and not to express category membership. The problem with recognizing categorization errors is that category is indicated by morphemes that have other grammatical functions.

If morphemes cause a problem of interpretation, this problem could in principle easily be solved by only looking at forms without grammatical markers. However, if the content words are not grammatically marked, we cannot decide if word forms have been categorized correctly. This fact is clearly stated by Eve Clark:

“The point is a methodological one: children in the earlier stages of acquisition may not make the same assignments to word classes that adults do, so we cannot automatically assume adult-like assignments until children’s terms appear with enough grammatical information to be certain.” (Clark, 1993: 39)

It is very hard – if not impossible – to recognize categorization errors if there is no grammatical information in the utterances. Since grammatical information is needed in order to decide whether an error has occurred, and since children generally start to produce grammatical structure at around 2 years of age, we can only look for categorization errors in children older than 2;0 (years;months). Aside from the fact that this is quite late for detecting the development we are interested in, there are other developments at this age that cause some challenges for the interpretation of these errors.

Children typically start to use nonexistent innovative words (‘errors’ in the sense of non-adult-like) after 2;0 when they develop more advanced lexical and morphological skills. Such errors should not be labeled categorization errors, since adults can invent new words in a comparable way (Clark & Clark, 1979). In §2.2.2, I mentioned the English example *Mummy trousers me* (Clark, 1982: 406) as an example of evidence for Borer’s (2004) prediction of categorization errors.

However, the form *trouser* with the verbal third person singular morpheme *-s* could be either an instance of a categorization error (the child's grammar allows *trouser* to be spelled out with a verbal morpheme) or, equally plausible, an innovation created to fill the lexical gap for 'putting on trousers' in the adult lexicon by means of a morphological zero-derivation of the nominal *trouser*. Due to the fact that the child lexicon is still developing, such innovations might also be used by children for concepts for which there is a word in the adult lexicon that the child has not learned yet. In these cases, the innovation resulting from a morphological operation is created to fill a lexical gap in the child's own lexicon that is not actually a lexical gap in the adult language. Distinguishing lexical errors resulting from a morphological operation from categorization errors is difficult because their surface form is exactly the same. This is not to say that such errors are not informative about the acquisition process, because they indicate aspects of lexical and morphological development. However, they are not necessarily indicative of the development of categorization. In adult English a substantial number of words can be used as both nouns and verbs (see also §1.1). If children hear the same word form being used with properties of different categories, they may assume that this is a possibility for all word forms. For example, the earliest reported candidate for a category overgeneralization in English in Clark (1993) is of 2;4-year-old Damon saying *I'm sanding* while grinding pepper, and afterwards referring to the result (the pepper grains) saying *look at the sand!* (Clark, 1993: 200, Table 11-1). The form *sand* can be both a verb and a noun in English, so using *sand* with the verbal ending *-ing* is not a categorization error per se. However, the meaning of the verb *sand* in adult language is different from the Damon's meaning (namely 'to smooth wood with sandpaper'). The question is whether Damon is making a categorization error here, or a semantic error concerning the meaning of the adult verb *sand*, or a morphological error concerning the derivational possibilities of *sand*.

In summary, there is an important problem to be dealt with in the interpretation of categorization errors. The morphemes that are indicative of category membership have other functions, such as the expression of tense or number. As a consequence, the surface form of categorization errors is identical to the surface form of morphological errors. If a word form can occur in multiple categories in adult language, the apparent categorization error can also be an overgeneralization of morphological possibilities, or even of meaning. In the next section I will investigate categorization errors in child speech bearing in mind that they may be morphological or semantic errors.

3.2.2. Analysis of categorization errors in Dutch

A corpus study of categorization errors in Dutch was conducted to investigate the compatibility of child language production data with the theories by Marantz and Borer. In the discussion of the results, special attention will be paid to whether the problems of interpreting these errors (see §3.2.1) can be overcome. The recordings of four Dutch children between about 2;6 and 3;6 years of age (Matthijs and Tomas, Wijnen, 1993; Laura and Sarah, Van Kampen, 1997), as archived in the Child Language Data Exchange System (MacWhinney, 1991), were selected for analysis. All child utterances in these recordings were checked by hand to see if there were any possible categorization errors. The working definition of a categorization error used for this analysis was the use of a Dutch word in a morpho-syntactic context in which it cannot be used in adult Dutch.

All observed candidates for category overgeneralizations in these files are listed in Table 3.1. The main finding of this study is that in all the data studied there are only 14 candidates for categorization errors. This is a very small number. To provide an idea of the ratio, 78 recordings were checked, approximately 200.000 tokens of child speech, so the 14 candidates for categorization error constituted about 0.007 % of all tokens in the analyzed corpora. This implies that the overwhelming majority of child utterances appear adult-like with respect to category. This impression will be systematically investigated in the longitudinal corpus study reported in the next section. In this stage of child language production, between 2;6 and 3;6, categorization errors are definitely not typical. The predictions based on proposals of Marantz and Borer is not borne out by these data. If children make categorization errors at an early stage of development, it is before 2;6.

Although the number of errors found is very small, it is worthwhile taking a closer look at them to see whether they can be interpreted as actual categorization errors. In order to determine whether these errors are indeed categorization errors and not semantic or morphological errors, all the candidates for overgeneralization error from Table 3.1 were analyzed with respect to the following three questions: (1) does the non-adult-like use of the word form fill a lexical gap in the adult lexicon?, (2) does the non-adult-like use of the word form fill a lexical gap in the child's lexicon?, and (3) does the word form occur in the category of the non-adult-like utterance in adult speech (with a different meaning)? If the answer to all these three questions is negative, the attested non-adult-like utterance can be interpreted as a categorization error. However, if the answer to one or more of the questions is positive, it is not straightforward how the error can be used to distinguish the child's categorization abilities from the child's morphological and semantic abilities.

The questions of whether the non-adult-like utterance filled a lexical gap in the adult's lexicon and whether the word occurred in the category of the non-adult-like utterance in adult speech were answered based on native speaker intuitions of the researcher. A lexical gap in the child's lexicon was established based on all available spontaneous speech transcripts of the child, including those where the child was younger than 2;6 and older than 3;6. If the presumably intended adult word did not occur in one of the child's transcripts when it was required for the context, it was assumed that the child did not have this word in her active lexicon.¹⁰

Table 3.2 shows that most candidates for categorization errors could also be morphological or semantic errors. Only one of the examples (*pannen*) cannot be analyzed as a lexical gap or multiple-category item. This might be due to the fact that it is not clear from the context what the child intends to say here. When the intended meaning is not clear, it is impossible to decide upon the appropriate label for it in adult language. Without the equivalent adult word, it could not be established whether this utterance fills a lexical gap. In support of the idea that these examples could equally well be overgeneralizations of meaning as categorization errors is the fact that in 13 of the 14 cases, the child also uses the lexical item in the adult category in one of the recordings (e.g., in the same transcript where Matthijs produces *veeg*, he also produces the correct derived form *veger* 'brush'). This indicates a certain flexible use of word forms that is not necessarily evidence for different representation of categories in the child grammar compared to adults. They could also be the result of creative analogy with zero-derived adult word forms such as *fiets_V* / *fiets_N* 'bike' and *drinken_V* / *drinken_N* 'drink', which are also used correctly in multiple categories from an early age onwards. Although these data provide interesting insights into the lexical and morphological abilities of these children, they do not contribute to a better understanding of their categorization skills.

This study showed that Dutch children produce a very small number of categorization errors. Furthermore, the problems of interpretation presented as a challenge in §3.3.1 could not be overcome in this study. Two conclusions can be drawn at this point: the theories of Marantz and Borer are not compatible with the language production data of these four Dutch children between 2;6 and 3;6, and the analysis of errors as a method to study categorization faces challenges that seem impossible to overcome. The size and method of this study does not allow us to draw firm conclusions about the adult-like use of words by Dutch children in general. Therefore, a more elaborate study of the categorization of verbs and nouns by Dutch children was conducted that also included data from slightly younger

¹⁰ Although the transcripts of course only contain a very small percentage of the children's total speech production, this is the only way in which the children's vocabulary could be assessed empirically.

Table 3.1. Overview of all candidates for categorization errors from a corpus study of four Dutch children between 2;6 and 3;6, structured according to the category of the adult word form from which the error is derived: nouns, verbs, and adjectives.

Non-adult-like utterance*	English translation (and intended meaning)	Adult word form	Age
NOUNS PRODUCED WITH VERBAL INFINITIVE MARKER <i>-E(N)</i>			
<i>hij gaat zo voeten</i>	'he goes to foot like that' (walk the way a crab walks)	<i>voet</i> 'foot'	2;9
<i>dupelē</i>	'to duplo' (play with duplo)	<i>duplo</i> 'duplo'	2;11
<i>hameren</i>	'to hammer'	<i>hamer</i> 'hammer'	3;1
<i>met de deksel pannen</i>	'to pan with the lid' (???)	<i>pan</i> 'pan'	3;1
<i>nee, ik wil mee gieteren</i>	'no, I want to watering-can with that' (pour water with watering-can)	<i>gieter</i> 'watering-can'	3;2
<i>ikke wil zalvē</i>	'I want to ointment' (to put on ointment)	<i>zalf</i> 'ointment'	2;7
VERBS PRODUCED WITH NOMINAL MARKERS <i>DE / HET / EEN</i>			
<i>die moet ook niet bij de zwemmen</i>	'that one must not with the swims, either' (those that swim)	<i>zwemmen</i> 'to swim'	2;10
<i>een veeg!</i>	'a sweep!' (brush)	<i>vegen</i> 'to sweep'	2;7
<i>dit is het tafeldekk</i>	'this is the lay-table' (tablecloth)	<i>tafeldekken</i> 'to lay table'	3;6
<i>ik wil de hoor</i>	'I want the hear' (headphone)	<i>horen</i> 'to hear'	2;11
ADJECTIVES PRODUCED WITH VERBAL MARKERS 3 RD PERSON SINGULAR <i>-T</i> AND PAST PARTICIPLE MARKER <i>GE-</i>			
<i>neusje viest</i>	'nosie dirties' (is dirty)	<i>vies</i> 'dirty'	3;7
<i>kijk, gestuk, stuk dat</i>	'look, made-broken, broken that' (has been broken)	<i>stuk</i> 'broken'	2;6
ADJECTIVES PRODUCED WITH NOMINAL MARKERS <i>(EE)N / DE</i>			
<i>is n heel mooi?</i>	'is a very beautiful?' (very beautiful one)	<i>mooi</i> 'beautiful'	2;8
<i>die gaan ook op de snel</i>	'those also go on the fast' (highway)	<i>snel</i> 'fast'	2;10

*Category-indicating morpho-syntactic markers are underlined.

children (2;0), to see whether the errors predicted by Marantz and Borer would occur at an earlier stage.

Table 3.2. Analysis of all candidates for categorization errors according to the possibility that they represent innovations (filling lexical gaps) or word forms that can occur in multiple categories in adult speech (see Table 3.1 for English translation). + stands for a positive answer to the statement at the top of the column, - stands for a negative answer.

Categorization error from Table 3.1	No word exists in adult language with the intended meaning	Adult equivalent word exists, but was not found in child transcript	Word occurs in this category in adult speech, but with different meaning
<i>voeten</i>	+	-	-
<i>dupele</i>	+	-	-
<i>hameren</i>	-	+ (<i>timmeren</i>)	+ (figuratively)
<i>pannen</i>	-	-	-
<i>gieteren</i>	+	-	-
<i>zalve</i>	+	-	+ (archaic)
<i>zwemmen</i>	+	-	-
<i>veeg</i>	-	-	+
<i>slaap</i>	-	-	+
<i>tafeldek</i>	-	+ (<i>tafelkleed</i>)	-
<i>hoor</i>	-	+ (<i>koptelefoon</i>)	-
<i>viest</i>	+	-	-
<i>gestuk</i>	+	-	-
<i>mooi</i>	-	+ (<i>mooie</i>)	-
<i>snel</i>	-	+ (<i>snelweg</i>)	-

3.3. A longitudinal corpus study of Dutch children's spontaneous speech

It is predicted by most of the theories discussed in Chapter 2 that children will show an adult-like, or an even more conservative than adult-like, use of words in syntactic patterns. To test this prediction in more detail than was done in the previous study of categorization errors, a longitudinal corpus study was conducted. The study was

designed to test the specific predictions made by Hengeveld (§2.4) and therefore uses his terminology. However, the results are relevant for all the theories other than those of Marantz and Borer, since the overall prediction is similar (§2.6).

As discussed in §2.4.2, Hengeveld's (1992b) functional theory of categories predicts that children learn to use word forms in syntactic functions in accordance with the implicational hierarchy presented in (14) in §2.4.2. Since the lexical expression of the syntactic function HP precedes the expression of HR, and both HP and HR precede the modifying functions in this hierarchy, it is expected that children will start using content words predicatively, and in a second stage also referentially. It is also expected that the verb-noun distinction will be made at some point early in development, before separate classes of adjectives and adverbs are present. In this section an analysis of spontaneous speech corpora of four Dutch children and four Dutch adults is reported (see also Erkelens, 2006) to test the general prediction that children will show an adult-like use of verbal and nominal forms in syntactic functions.

3.3.1. Method

In this corpus study every content word (as opposed to function word) used in a number of child and adult transcripts was analyzed. The transcripts used came from four children in CHILDES (MacWhinney, 1991) and four adults in the *Corpus Gesproken Nederlands* 'Spoken Dutch Corpus' (Oostdijk, 2000). The adult data were included in the study to set a baseline of how content words are used in Dutch. Adult-to-adult speech was used instead of adult-to-child speech because this would provide a better baseline measure. Child-directed speech often consists of shorter and less complex sentences and hence probably does not contain the full array of the syntactic possibilities of Dutch. The child transcripts are from the children Daan and Matthijs (Dutch *Groningen* corpus, Wijnen, 1993) and Sarah and Laura (Dutch *Van Kampen* corpus, Van Kampen, 2004). A selection of the transcripts was made based on the Mean Length of Utterance (henceforth MLU - Brown, 1973) measured in morphemes. In early acquisition MLU is a better indicator of the stage of linguistic development than age because children differ in the speed of acquisition. As discussed earlier, word classes cannot be assigned to single words produced by children, because there is no grammatical information available to tell what the assignment is. Therefore, a minimal syntactic context (i.e., more than one word) is necessary for any analysis. A minimum MLU of 1.8 was set since it is likely that the majority of the child's utterances at this point are two words or longer. Analysis was continued until the children's MLU was about 3.6 based on the availability of data. The age of the children ranged from 2;0:17 (years;months:days) to 3;7:25. The adult

transcripts used were two randomly chosen face-to-face conversations involving two adults. These conversations were divided into four separate transcripts, one per adult. The total number of utterances per adult is much smaller than that of the children. As the adult data serve as a baseline for comparison, a small amount of data is sufficient if the analyzed transcripts of the different adults show a comparable pattern. This was the case. Of the 83 transcripts (79 child and 4 adult transcripts), every content word was coded for both its *word class* in adult Dutch and for the *syntactic function* in which it was used.

The *syntactic functions* coded in the corpora are those reported in §2.4.1. They are taken from Functional Grammar: Head of a Predicate phrase (henceforth HP), Head of a Referential phrase (henceforth HR), Modifier in a Referential phrase (henceforth MR), and Modifier in a Predicate phrase (henceforth MP). These syntactic functions are more or less comparable to the categories more commonly known from generative grammar as head of VP, head of NP, head of AP, and head of AdvP. However, since the syntactic functions were coded independently of the lexical items used in them, the terms V, N, A, Adv were reserved for word classes in order to keep the terminology clear. The implication of this separation of syntactic functions and word classes in Functional Grammar is that the head of the predicate phrase does not have to be a verb, whereas the head of the VP does. For example, in the sentence ‘John is president’ (example (12) in §2.4.1), the HP is ‘president’, whereas ‘president’ can never be the head of a VP, since it is not a verb. The following criteria were used for coding a syntactic function:

- HP: the lexical item qualifies a present utterance or object, without being the term for that object.
- HR: the lexical item refers to an object or concept for which it is the term.
- MR: the lexical item is a modification of the HR (the part that refers to an object or concept for which it is the term).
- MP: the lexical item is a modification of the HP (the part that qualifies a present utterance or object, without being the term for that object).

It is important that the coding of the syntactic functions was conducted with as little interpretation of nonexistent information as possible. Child utterances are often syntactically and morphologically incomplete and therefore hard to analyze. In a rich interpretation the researcher makes assumptions about the missing structure. This is not the kind of interpretation that was used in this study. For the initial coding the child’s utterance was only given credit for the word forms that were actually produced. Even if the syntactic function of a word form would have been different if a presumably omitted function word had been present, the syntactic function coded was based on the child’s actual utterance. That is, the position of the

word in the child utterance and the produced morphological markers were taken as indicators of the syntactic function. We will see in the discussion of the results that for some syntactic functions a reanalysis with limited assumptions about omitted structure is necessary.

An unclear (Unclear) option was added since the syntactic function of a word cannot always be determined on the basis of the limited set of data available in the transcript. One-word utterances, for example, are almost always unclear as regards the syntactic function since there is no overt syntactic structure in the utterance itself. Words can only be used predicatively, referentially, or as modifiers in relation to other words in the utterance. Wherever possible, the context of an utterance was used to make inferences about the most likely syntactic function of the word used. All content words that did not clearly express one of the four syntactic functions were coded as having an unclear syntactic function.

The coding of *word class* was based on the intuition of native speaker coders as outlined above. The assigned content word classes are: verb (V), noun (N), adjective (A), and proper name (PrN). Not all lexical words fall into one of these four categories. Therefore, a category ‘Other’ was included, which contained adverbs, adpositions, and words that were ambiguous between verb and noun. In the discussion of the results below, the precise contents of the ‘Other’ category are further analyzed when relevant. For the assignment of the word class labels, the coders were naïve with respect to the context and the syntactic category in which the lexical items were used. The word class that was most strongly associated with an item was assigned based on intuition, irrespective of the context or the more peripheral categorization possibilities of the word. For example, the English content word *sand* would have been coded as a noun since this is the most strongly associated word class for adult speakers of English. However, the earlier examples of a child’s lexical innovations showed that this word can be used in a verbal syntactic context as in *I’m sanding* (see §3.2.1). The word *sand* also has a verbal meaning in English, as in *He sands the door*. Only if the coder really felt that the word was equally likely to be a verb or a noun was the label V/N applied. In all other cases where one word class label stood out as the most natural, this label was assigned. For example, *zalve* in *ikke wil zalve* ‘I want to ointment’ (see Table 3.1 in §3.2.2) was labeled as a noun, although according to the online *Van Dale*¹¹ it can also be a verb. Even for words with a verbal use in modern Dutch, such as the Dutch *huiz-en* ‘house-INF’, the word was coded as a noun in the utterance *ditte huisje* ‘this

¹¹ Online version of the renowned Dutch dictionary published by the company Van Dale on their website: <http://www.vandale.nl/vandale/opzoeken/woordenboek/?zoekwoord=zalven>, consulted by the author on March, 5, 2009.

house-DIM' because noun is the word class most strongly associated with the form *huis* 'house'. By basing the word class label on adult speakers' intuitions, the word class is kept as an independent variable in both children and adults. Note that this coding for word class does not imply that the child has the same word class label for the word in her lexicon. Rather, it functions as an independent measure of the kind of lexical item that is used. For a subset of the data (about 15 %), two or more coders labelled the word classes. The intercoder reliability for this subset was always above 90%. The codings of the principal coder were taken in cases of disagreement.

3.3.2. Results

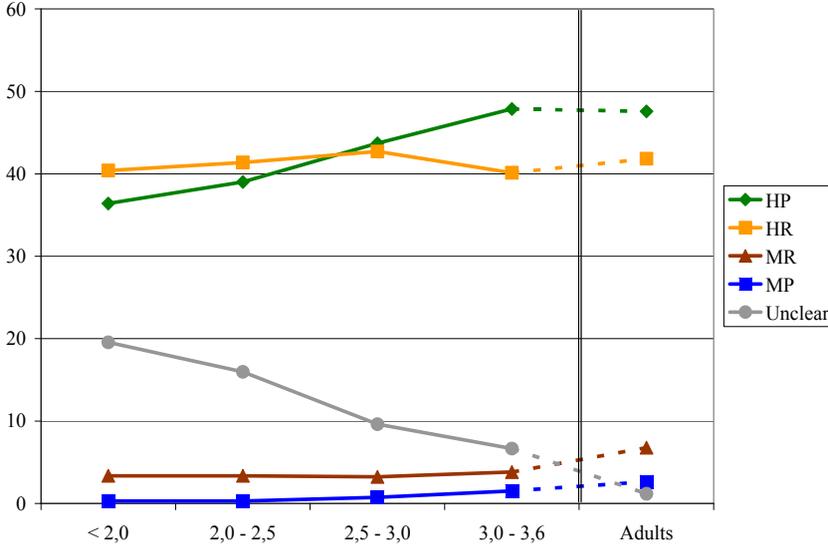
According to Hengeveld (1992b), languages differ from each other in their number of word classes. Dutch is characterized as a language with three word classes: verbs, nouns, and adjectives. Dutch verbs function as the HP, nouns can function as the HR, and adjectives can function as both the MR and the MP. The two modifying syntactic functions are thus expressed by a single word class, as shown in example (1).

- (1) [*Een* [*mooi*]_{MR} [*meisje*]_{HR}]_{Ref. phrase} [[*zing-t*]_{HP} [*mooi*]_{MP}]_{Pred. phrase}
 A beautiful girl sing-3SG beautiful
 'A beautiful girl sings beautifully'

As we will see in the data, nouns and adjectives can also be used predicatively. The prediction from the hierarchy of syntactic functions is that the modifying functions will be expressed lexically later in development than the referential and predicative functions. The coded child language corpora were analyzed to investigate how Dutch children learn the different possibilities of content word classes for expressing syntactic functions. First, the analyses of how the syntactic functions are expressed lexically over time will be presented and then the word classes used for each syntactic function will be discussed.

Figure 3.1 shows which syntactic functions are expressed with content words by the children and the adults. The lines represent the percentage of content words used for a specific syntactic function and the data points each stand for a certain MLU group, as indicated on the x-axis. The data presented in this graph show that even the youngest children, who have an average MLU below 2.0, express three syntactic functions lexically: HP, HR, and MR. Examples from this youngest group are provided in (2) and (3).

Figure 3.1. Percentages of the syntactic functions HP, HR, MR, and MP expressed with a content word by Dutch children at different MLU points and by a control group of Dutch adults.



(2) $[[lieve]_{MR} \quad [bal]_{HR}]_{Refphrase}$ (Sarah, 2;0;17 - MLU=1.7)
 sweet ball

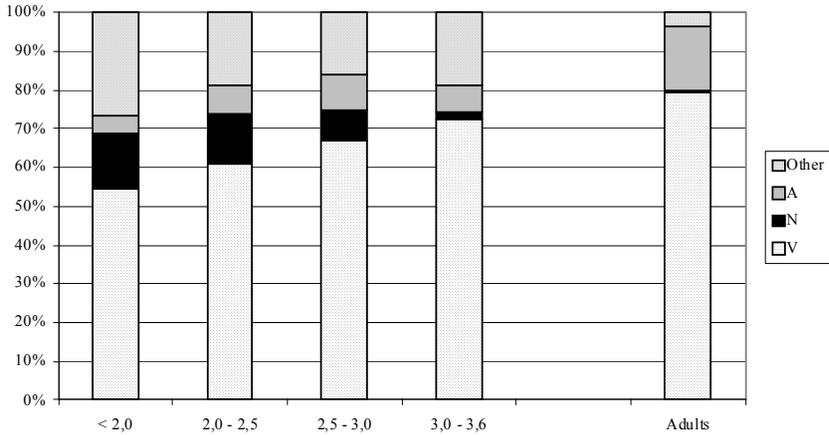
(3) $[Pepijn]_{HR, Refphrase} [teken-en]_{HP, Predphrase}$ (Daan, 2;4;14 - MLU=1.9)
 Pepijn draw-INF

Even in their earliest word combinations, children express at least three different syntactic functions by means of content words. The finding in these data that children do not express the syntactic function MP with content words until they have an MLU of above 2.5 can be due to the relatively low number of words used in MP in everyday speech overall. Even the adults express the MP function in only 2.65 percent of their lexical expressions. The results per syntactic function are provided to establish whether there is a development in the word classes used in each function.

Let us start with the syntactic function HP. Figure 3.2 shows the word classes used by both children and adults to express this function. The raw numbers of content words used in each syntactic function are provided in Appendix 3.1. The

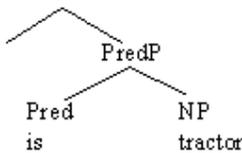
- (5) [*dat*]_{HR, Ref. phrase} [*is*] [*trekker*]_{HP}_{Pred. phrase} (Matthijs 2:9;15 – MLU=2.3)
 that is tractor

Figure 3.2. Percentages of content words per word class used by children at different MLU points and a control group of adults to express the syntactic function HP (A = adjective, N = noun, V = verb).

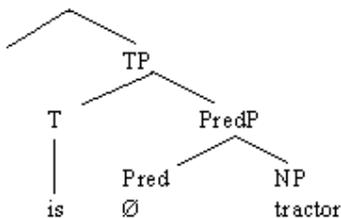


Note that in a generative syntactic analysis the noun is not the head in a copular construction (Baker, 2003). The head of the predicate phrase would be either the auxiliary ‘is’ (6) or an empty predicating head (7).

- (6)



- (7)



The present study followed the functional syntactic analysis of these phrases proposed by Hengeveld (1992b) according to which the lexical items used predicatively in a copular construction are themselves the head of the predicate phrase, e.g., *trekker* in (5). This is a consequence of the centrality of the notion predication in Functional Grammar: every lexical item has a predicative variable and can be characterized as the head of a predicate phrase. The copula is only a language-specific consequence of the fact that a nominal item is used predicatively; it has no syntactic function in itself. The functional analysis of the utterance ‘*dat is trekker*’ according to FG-notation is provided in (8).

$$(8) (p_i: [(e_i: [(f_i: \textit{trekker}_N) (\text{prox } x_i :<-\text{anim}>)_\theta] (e_i))] (p_i))$$

This says that there is a propositional content (p_i), such that there is a state-of-affairs (e_i), such that the property (f_i), *trekker*, is predicated over a proximate, inanimate object (x_i). The copula plays no role in the underlying functional structure of the utterance. The analysis would have been exactly the same if the child had omitted the copula. The coding followed the FG interpretation, so the noun *trekker* in (5) was coded as HP. However, it is equally valid to code this as HR since it is also the term for the object ‘tractor’. The lexical item *trekker* would then in and of itself be an entire referential phrase and that phrase would be the head of the predicate. The interpretation of such utterances is decisive for the coding applied to the syntactic function for which the word is used. If the coder interpreted the content word not as referring to the object but rather as qualifying ‘that’, the syntactic function was HP. However, had the child expressed this utterance with a determiner such as *een* in (9), the interpretation could only be that the content word itself was the term for the object, since it can no longer be predicating ‘that’ by itself. The entire referential phrase might still be interpreted as expressing the HP according to the criteria we used for syntactic coding, but the lexical item *trekker* can only be head of the referential phrase that as a whole is predicating *dat* (10).

$$(9) [\textit{dat}]_{\text{HR, Ref. phrase}} \quad [\textit{is}] \quad [\textit{een}] \quad [\textit{trekker}]_{\text{HR}}]_{\text{HP, Ref. phrase}}]_{\text{Pred. phrase}}$$

that is a tractor

$$(10) (p_i: [(e_i: [(f_i: [(x_i: (f_k: \textit{trekker}_N) (f_k)) (\text{prox } x_i)_\theta] (e_i))] (p_i))$$

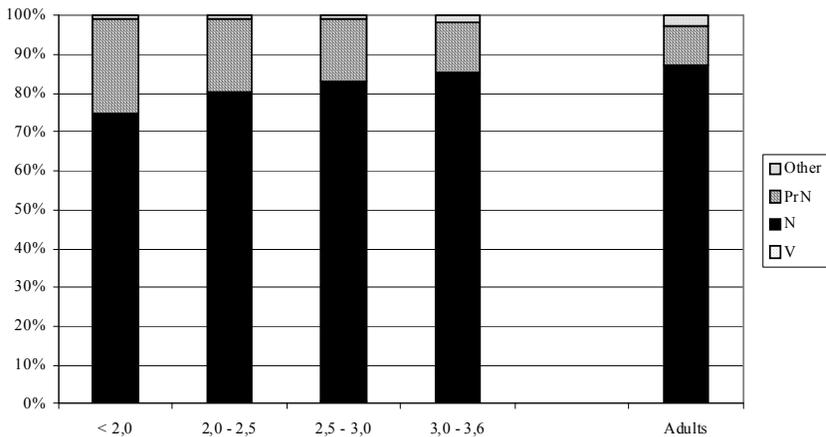
In the higher MLU groups and with the adults, the obligatory determiners are almost always present if nouns are used.¹³ Nouns with explicit determiners were never

¹³ It is possible in Dutch to use nouns predicatively without a determiner, but only with a restricted set of profession-indicating predicates (e.g., *hij is bakker* ‘he is baker’).

coded as HP in the files of older children and adults. Since the point at which the children show a decrease in the number of nouns used as HP coincides with the point at which Dutch children are known to acquire the obligatory use of determiners (Van der Velde, 2003; Rozendaal, 2008), the apparent over-use of nouns in HP is most likely a consequence of determiner omission and not of the acquisition of categories, but the interpretation remains ambiguous.

Another problem of interpretation concerns children's two-word-combinations of pronoun and noun, or noun and noun, as in *I tea* or *daddy cookie*. These examples are comparable to the utterance *dat trekker* discussed above. Again, the syntactic function of *tea* and *cookie* could be HP, because they predicate *I* and *daddy*. However, *tea* and *cookie* can also be used as an argument with an omitted verb such as 'want(s)'. Without morphological marking and detailed information of the context of the utterance, it is hard to decide which coding is the most appropriate.

Figure 3.3. Percentages of content words per word class used by children at different MLU points and a control group of adults to express the syntactic function HR (PrN = proper noun, N = noun, V = verb).



Parallel to Figure 3.2 for the HP, Figure 3.3 presents the results for the syntactic function HR. There is hardly any development in the data for this syntactic function, especially if proper names are taken as part of the noun category. All child groups and the adults almost exclusively use nouns or proper names to express the HR. The most important differences are observable in the relative proportions of proper names versus nouns. Children with a lower MLU tend to use more proper names

than children with a higher MLU and adults. Although this issue was not analyzed further because it is beyond the scope of this study, it is conceivable that children in the early stages of language development use fewer functional words to refer to persons than adults because they are pragmatically difficult (e.g., third person pronouns). As a consequence, they tend to use the proper name of the person or animal itself to refer to them.

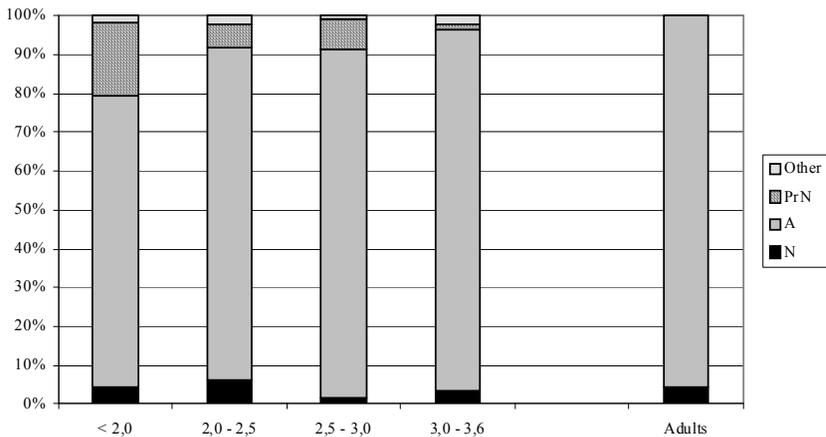
The third syntactic function analyzed is the modifier in a referential phrase (MR). In Figure 3.4, the word classes to express this function are again visualized as percentages of the total number of content words used to express this function. In the syntactic function MR, for the first time a qualitative difference between the children and the adults can be observed. All children use a word class that adults never use to express the MR, namely proper names. Examples of these proper name uses are provided in (11) and (12).

- (11) *op Evelien schoot-je* (Matthijs, 2:07;23 – MLU = 2.8)
 on Evelien lap-DIM
 ‘on Evelien(’s) lap’
- (12) *dis papa huis* (Laura, 2:05;00 – MLU = 2.2)
 this.is daddy house
 ‘this is daddy(’s) house’

All four children showed similar uses of a proper name indicating the possessor in the MR function without addition of a genitive marker. Dutch has two genitive markers: the *-s* ending similar to English, and the possessive pronoun (e.g., *op Evelien d'r schootje* ‘on Evelien her lap’, *dis papa z'n huis* ‘this is daddy his house’). The data of the children did contain the possessive *-s* ending in other utterances of the same transcripts, but it is not rare for children to show optionality in the omission of grammatical markers. Another explanation for the fact that they omit the ending here is that they omit the prosodically weak possessive pronouns *d'r* ‘her’ and *z'n* ‘his’. Using a combination of a proper name and such a weak possessive pronoun is a very common way to express modification in spoken Dutch. Example (12) would have been adult-like if Laura had said *dis papa z'n huis* ‘this is daddy his house’. In that case the MR is actually not expressed by the proper name, but by the possessive pronoun *z'n*. An alternative interpretation could be that the children use the proper names as the first part of a compound (i.e., not a *poppenhuis* ‘doll’s house’, but a *papahuis* ‘daddy’s house’). Although in adult Dutch a compound requires a determiner in this context, we see in Figure 3.4 that the use of proper names in MR is the highest in those MLU groups (< 2.5) where children still

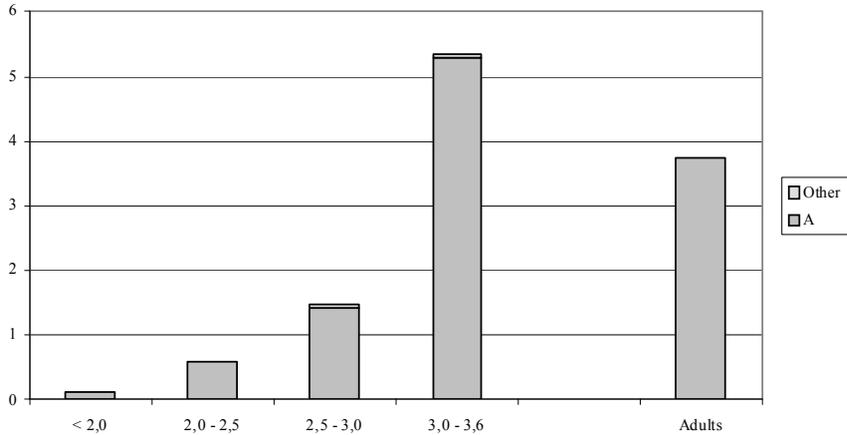
omit the determiners. Both the omission of possessive pronouns and the omission of determiners with compounds are problems in the acquisition of morphology, and not problems of category.

Figure 3.4. Percentages of content words per word class used by children at different MLU points and a control group of adults to express the syntactic function MR (PrN = proper noun, A = adjective, N = noun).



The last syntactic function studied is the MP. Since the number of content words used to express MP is very low across all transcripts, these data are not presented as percentages but as average numbers. Note that the length of the bars as a whole is not very informative, since the groups differ greatly in the number and size of the transcripts. The average number of words from a certain word class used in MP are presented in Figure 3.5. The few content words used in MP are almost all adjectives. The instances of 'Other' word classes used to express this function are mainly adverbs that cannot be used attributively such as *zachtjes* 'softly', or *erg* 'very'. All children only used lexical items in this syntactic function that adults would also use; in this respect they are adult-like from the start.

Figure 3.5. Number of content words per word class used by children at different MLU points and a control group of adults to express the syntactic function MP (A = adjective).



3.3.3. Conclusion

The longitudinal corpus study of Dutch children's and adult's spontaneous speech reported here shows that Dutch children perform almost like adults with respect to the use of verbs, nouns, and adjectives across syntactic functions. The differences between children and adults shown by the codings for the syntactic function HP could be attributed to the omission of determiners and pronouns by the younger children. A re-analysis was made of the first non-rich interpretation of the material. Since we know from independent evidence that children in the lowest MLU groups leave out the determiners in obligatory contexts systematically, it seems legitimate to assume syntactic structures in which a determiner would have been produced. If this assumption is made about the nature of the material that was omitted, we do not find any clear developmental stages in the development of word class use over syntactic functions. The children used verbs only predicatively; they used nouns in diverse syntactic functions mostly comparable to adult use; and they used adjectives both predicatively and attributively.

The results from the small corpus study reported in §3.2 on categorization errors are confirmed by this detailed longitudinal corpus study on categorization in general. From the moment children start to combine words, they use these words syntactically according to the adult pattern. This outcome is compatible with

different interpretations of the underlying verbal and nominal representations, including those of Baker, Hengeveld, Croft, and Goldberg are all compatible with these child language production data. Dutch two-year-olds categorize their words in a way that results in adult-like use. Whether the grammars of these children contain the same categories as the grammars of Dutch adults remains an open question.

3.4. Conclusions

The studies presented in this chapter tested which of the theories discussed in Chapter 2 are compatible with Dutch children's production data. The analyses of spontaneous speech corpora revealed that categorization can only be studied in production if children produce sentences (i.e., more than one-word utterances) with grammatical information. Once they do this, they use the majority of their words according to the adult-like syntactic possibilities. Children have at least initial categories of words from the moment that word combinations can be observed.

This outcome seems incompatible with the theories that predicted that categorization errors would occur in an early stage of development. These errors were hardly attested in the children's spontaneous speech. But the predicted error stage might occur before the age at which production data can be investigated. So, in fact, the adult-like production patterns are at this point compatible with all of the radically different ideas about the representation of verbs and nouns in the grammar. The production studies in this chapter have shown that children already categorize their words correctly from the moment categorization can be studied in their spontaneous speech. The nature of these child categories cannot be assessed with the methods used in this chapter. Since the difference between the theories of verbs and nouns revolves mainly around the nature of their representations, these data cannot distinguish between the different proposals.

The intriguing question now is whether it is possible to study the categorization abilities of younger children. If we can determine how children arrive at the categorization abilities they have at two years of age, we can shed some light on the nature of the categories they have at this age. The next chapter will discuss methods for studying younger children, and the properties of the input speech that are indicative of the categories verb and noun.

4 Category-indicative properties of Dutch input

The results from the production studies in Chapter 3 have shown that children already have initial word class categories from the moment their categorization abilities can be assessed in production. In order to gain more insight into the process of how children learn to categorize, the knowledge of younger children needs to be studied, using data other than from sentence production. Before the perception of categories in younger children is studied in Chapter 5, in this chapter Dutch adult language is studied to identify category-indicative properties that are available to pre-verbal infants. Two properties are under investigation here, namely phonological properties and co-occurrence patterns of words and morphemes. An experimental study on the use of phonological form as an indicator of category by Dutch adults is reported first (§4.2). Then an input study on the presence of so-called ‘frequent frames’ (frequent co-occurrence of two non-adjacent words) is reported (§4.3). The outcomes are discussed and elaborated with a proposal concerning the relevance of frequently co-occurring non-adjacent morphemes in Dutch. This chapter finishes with by presenting and discussing methods to study language perception in infants (§4.4).

4.1. Introduction

As shown in the production studies in Chapter 3, children are able to distinguish verbs and nouns once they produce sentences. Their input language apparently contains category-indicative properties that enable them to start categorizing words as verbs and nouns at a very early stage of development. Since infants become sensitive to the phonemic categories of their first language already between 6 and 9 months of age (Jusczyk, 2002), phonology is the first candidate for category-indicative properties that are available early. If the phonological form of words is indicative of category, children may benefit from these links in an early stage of development. Therefore, the availability of phonology as a category-indicative property in Dutch will be studied here first.

Studies indicate that English-learning infants are able to segment words in an ongoing speech stream from 9 months onwards (Jusczyk, Hohne, & Bauman, 1999; Mattys & Jusczyk, 2001). This ability to segment the utterance into phonological words makes the co-occurrence patterns of those words accessible for these 9-month-olds. The statistical distribution of words in sentences (co-occurrence patterns) is thus the second candidate for a category-indicative property that is

available early. The availability of co-occurrence patterns as an indication of the category of intervening words in Dutch will be studied in § 4.3.

To test whether the available category-indicative properties in Dutch are also used by Dutch infants in early categorization, a proper method is needed to test pre-verbal infants. Young infants' perception can be measured by means of experimental techniques like the Head-turn Preference Procedure. Such techniques provide important empirical evidence for early language development. However, the methods also have their limitations. In §4.4 the suitability of these methods to test early categorization will be discussed. Attention will be paid to the interpretation of this kind of data in general and more specifically to the interpretation of data on categorization.

4.2. Category-indicative phonological properties: an experimental study of adult Dutch¹⁴

For a long time, phonology and prosody were regarded as unreliable cues for determining categories because of their highly language-specific and arbitrary nature (e.g., Hockett, 1960). However, Morgan & Demuth (1996) introduced the term 'phonological bootstrapping', thereby proposing that the speech stream contains phonological information that leads to grammatical information, among which the lexical categories of words. Kelly (1996) showed that the phonological features stress pattern, number of syllables, duration, vowel quality, consonant quality, and number of phonemes correlate highly with grammatical class in English and that human beings are sensitive to these cues. Cassidy & Kelly (1991) showed that English 4-year-olds are sensitive to the number of syllables in words as a cue to their grammatical class. They presented nonsense words of one, two or three syllables and asked the children whether they thought the nonsense word referred to the action or to the object in a videotaped event. The children more often associated the action with the monosyllabic nonsense words than with the tri-syllabic nonsense words.

Subsequent work with artificial learning mechanisms confirms that phonological information can be used for lexical categorization. Durieux and Gillis (2001) showed that learning algorithms can successfully distinguish categories on the basis of phonological information alone. They studied the discrimination of three different lexical categories: verb, noun, and adjective. Their artificial learning system had to

¹⁴ This section is based on Don, J. & Erkelens, M.A. (2008) "Possible phonological cues in categorial acquisition: Evidence from adult categorization". *Studies in Language* 32(3), 670-682, and is used with kind permission by John Benjamins Publishing Company, Amsterdam/Philadelphia. www.benjamins.com.

predict the lexical category of a word, using only phonological and prosodic information. Several experiments were conducted, varying in target language and cue combination. The overall results showed that, both in English and Dutch, the learning system predicted the lexical categories most successfully if learning was done on the basis of raw segmental data from the target language. Although phonological cues like those presented by Kelly (1996) provide useful bootstrapping information, even purely simple segmental encoding in onset, nucleus, coda and stress pattern provides information about category. Durieux and Gillis (2001) concluded that the link between phonology and lexical category might function as a cue in category acquisition.

Other computational linguists have elaborated on these findings recently. On the basis of a corpus analysis, Monaghan, Chater and Christiansen (2005) showed that phonological cues can be especially useful in categorizing low frequency items. This corpus-based prediction was corroborated in an artificial language learning experiment, suggesting that learners may indeed use this kind of information to categorize items. In a further series of experiments Farmer, Christiansen and Monaghan (2006) showed that in processing English words subjects are sensitive to the word class typicality of a phonological form; a noun that has the typical phonological form of nouns is more easily processed than a noun that does not. Typicality was expressed as the 'phonological distance' from other members of the same category. Their results show that English speakers are indeed sensitive to such phonological typicality. Monaghan and Christiansen (2006) concluded, on the basis of their simulations, that although the relationship between individual word forms and meaning is arbitrary, the relationship between groups of word forms and their grammatical category shows a fair amount of systematicity.

A corpus analysis of child-directed speech by Monaghan, Christiansen and Chater (2007) shows that English, Dutch, French and Japanese all contain a considerable number of phonological cues that can lead to the accurate categorization of words as verbs and nouns. Although the specific phonological cues that are informative differ across languages, correlations between certain phonological properties and categories are available in typologically quite different languages such as English and Japanese.

As shown by Durieux & Gillis (2001) and Monaghan et al. (2007), Dutch phonology is also category-indicative to some extent. The next question is of course whether speakers of Dutch are able to use this category-indicative information. Farmer et al. (2006) showed for English that adults are able to use the phonological typicality of words for categorization. The experiment reported in this chapter confirms these results for Dutch, but the method and the type of phonological cues

that are tested differ. The aim was not to test sensitivity to the gradual notion of typicality, but sensitivity to well-defined properties (impossible forms) of the phonology of Dutch verbs that were first brought to light by Trommelen (1989).

There are several generalizations in Dutch that relate the phonological form of a (content) word to its lexical category, as Trommelen showed in 1989 and others later, as discussed above. An experiment was conducted to test whether in assigning lexical categories to nonsense words, adult native speakers of Dutch are able to use the phonological cues that can be deduced from Trommelen's generalizations.

4.2.1. Research question and predictions

By analyzing all possible clusters in Dutch verbs and nouns, Trommelen (1989) showed that the complexity of final rhymes in underived words can be an indication of word class. With respect to verbs, Trommelen observed that, generally speaking, they conform to a set of phonological restrictions. Many phonological forms that would make perfect nouns in Dutch do not occur as verbs. Based on Trommelen's (1989) observations, the following generalizations can be formulated about the phonological form of underived verbs in Dutch:

- verbs are monosyllabic;
- verbs do not end in a monophthongal vowel (including schwa), except for *ga* [xa] 'go', *doe* [du] 'do', *sta* [sta] 'stand' and *zie* [zi:] 'see';
- rhymes larger than three elements do not occur in verbs, apart from *peins* [pɛ̃ns] 'to consider', and *veins* [vɛ̃ns] 'to pretend';
- verbs ending in schwa followed by [m] do not occur.

There are some exceptions to these phonological restrictions, but in those cases the words are either denominal, foreign, or extremely rare. The possible phonological form of an underived verb thus forms a proper subset of the possible phonological form of Dutch (underived) words. Only nouns can have the full range of possible phonological forms.

The first of Trommelen's generalizations requires some explanation. With respect to their phonological make-up, typical Dutch verbs come in two types: monosyllabic or bi-syllabic with schwa as the kernel vowel of the final syllable. Kager & Zonneveld (1985) argue that phonologically speaking, 'bi-syllabic with schwa' in fact means 'monosyllabic'. If we adopt this analysis, we can confirm the

monosyllabicity generalization above, even though there are a small number of counterexamples.¹⁵

It is important to note, as Trommelen did, that there are in fact two types of verbs that apparently do not obey the above-mentioned generalizations. First, there are verbs ending in the affix *-eer* (*argument-eer* ‘argue’; *public-eer* ‘publish’). These verbs are clearly derived, whereas the phonological generalizations only hold for underived verbs. Second, there are seeming counterexamples like *olie* [oli] ‘to oil’ and *ruzie* [ryzi] ‘to quarrel’, but these verbs all have phonologically identical and semantically related nominal or adjectival counterparts. Therefore, these verbs can be safely assumed to be conversions of these ‘underlying’ adjectives, or nouns. For example, the verb *olie* is evidently derived from the phonologically identical noun *olie* [oli] ‘oil’, and it can safely be assumed that the same holds for the verbal *ruzie* and its nominal counterpart. Moreover, independent evidence indicates that the seeming counterexamples can safely be regarded as ‘conversions’ (see Don, 1993).

Nouns can have all characteristics listed above and more besides. ‘True’ polysyllabic nouns that is, nouns with more than a single full vowel are abundant (*gordijn* [xɔrdɛɪm] ‘curtain’, *banaan* [banan] ‘banana’, *antenne* [antənə] ‘antenna’, *cement* [səmənt] ‘cement’ etc.). There are also nouns ending in monophthongal vowels also exist (*zee* [ze] ‘sea’, *la* [la] ‘drawer’, *dominee* [domine] ‘vicar’, *knie* [kni] ‘knee’, *po* [po] ‘potty’, etc.), as well as nouns with rhymes of more than three elements (*angst* [ɑŋst] ‘fear’, *herfst* [herfst] ‘autumn’, *oogst* [oxst] ‘harvest’). There are also several nouns ending in schwa (*kade* [kadə] ‘quay’, *commune* [kəmyɲə] ‘commune’) or in schwa followed by an [m] (*bezem* [bezəm] ‘broom’).

These connections between the phonological properties of words and their category in Dutch can be translated into predictions for the use of these properties in categorization by adults. The question in (1) follows from this observation; that the possible phonological form of an underived Dutch verb forms a proper subset of the possible phonological form of Dutch underived nouns, and forms the basis for the experiment to be reported in this section.

- (1) Do Dutch adults use the differences in the possible phonological forms of verbs and nouns, as observed by Trommelen (1989), to categorize nonsense words?

¹⁵ So far the following counterexamples were found to the generalization that Dutch underived verbs exist only in a single syllable: *bakkelei* [bakələi] ‘fight’, *plavei* [plavəi] ‘pave’, *ravot* [ravot] ‘romp about’, *kriol* [kriul] ‘teem’, *poleist* [pələist] ‘polish’.

The prediction following from the subset – superset relationship between verbs and nouns is that words with a richer phonological make-up than is allowed for underived verbs will be classified as nouns by adult speakers. That is, words with one or more of the typically nominal characteristics will be classified as nouns. This prediction is formulated in (2).

- (2) Dutch adults use phonological characteristics to categorize content words as nouns or non-nouns, because the possibilities for the form of underived verbs constitute a subset of the possibilities for the form of underived nouns.

4.2.2. Method

The experiment used to test the prediction in (2) is a decision task: participants had to decide whether certain nonsense stems were nominal or verbal. Using nonsense stems in isolation is a good way to test phonological awareness. The participants' semantic, morphological, and syntactic knowledge is ruled out because nonsense stems have no meaning, morphological structure or sentential context. Of course, subjects possibly interpret some nonsense forms as morphologically complex, but the phonological form of the nonsense forms was constructed in such a way that they contained no recognizable Dutch affix. The assumption was that although many nouns in Dutch can be 'converted' to verbs without any overt phonological affix, subjects would still tend to first recognize such words as nominal rather than verbal.

The specific properties that define a particular stimulus as 'nominal', are the properties listed in (3).

- (3) Phonological characteristics typical of underived nouns in Dutch:
- true polysyllabicity (more than one full vowel)
 - ending in a long vowel
 - 'more than super-heavy' rhymes (VVCC or VCCC)
 - final schwa
 - final syllable consisting of schwa, followed by [m]

A set of 20 nonsense stems was created, all phonologically possible stems in Dutch. Of these 20, 11 were designed as nouns, according to the generalizations in (3). The other 9 stems were designed to be ambiguous between nouns and verbs. In Table 4.1, the stimuli are listed together with the design principles.

Table 4.1. Overview of the stimuli used in the classification experiment with their Dutch orthography, phonetics, condition and design principle.

	Phonetics	Condition	Design principle
donkam	dɔŋkam	Noun	Bi-syllabic
meliens	melins	Noun	
giveno	xiveno	Noun	Final long vowel
strempa	strɛmpa	Noun	
smoza	smoza	Noun	
boogst	boxst	Noun	Heavy rhyme
pierst	pirst	Noun	
riele	rilə	Noun	Final schwa
krile	krilə	Noun	
fallem	fələm	Noun	Final schwa + m
wirfem	wɪrfəm	Noun	
book	bok	Ambiguous	
pluig	plœ̃ix	Ambiguous	
diel	dil	Ambiguous	
drauf	drœ̃uf	Ambiguous	
blaaip	blap	Ambiguous	
nort	nort	Ambiguous	
krei	krɛ̃i	Ambiguous	
balter	baltər	Ambiguous	
kleest	klest	Ambiguous	

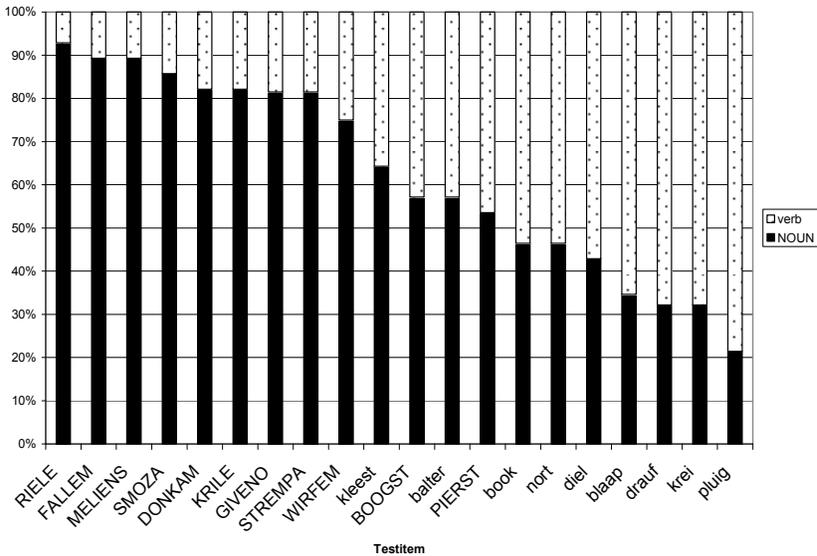
The participants of the experiment were 28 adults whose native language was Dutch. The stimuli were randomized and presented on paper with a brief introduction. The participants were asked to choose for each of the presented words whether they were stems of nouns or stems of verbs. In order to make sure that the subjects understood the notion of a ‘stem’, examples were provided of both a nominal and a verbal stem in Dutch. Moreover, the terms ‘nominal’ and ‘verbal’ were briefly introduced and the task was explained. The precise instructions are included in Appendix 4.1. The task itself was presented as a three-column sheet. In the first column all stimuli were listed. The second and the third column were headed by ‘nominal’ and ‘verbal’ respectively. The participants were asked to tick only one of the columns for each stimulus; the nominal column if they thought the

stimulus was a nominal stem, and the verbal column if they thought it was a verbal stem. All participants confirmed that they understood the task before proceeding.

4.2.3. Results

First, a general picture of the outcomes of the decision task will be provided. Then, the results will be analyzed in more detail to determine which phonological generalizations are taken to be the most reliable indicator of category in Dutch.

Figure 4.1. Percentages of noun and verb responses per stimulus designed either as a noun (in CAPITALS) or as ambiguous in the phonology experiment with Dutch adults.



A first look at the data shows some general patterns across the participants. Figure 4.1 depicts the percent of participants that judged each stimulus as either nominal or verbal, with the stimuli ordered from left to right in terms of decreasing likelihood of being categorized as a noun. For example, a large majority of the participants categorized the stimuli ‘riele’, ‘donkam’, ‘giveno’, and ‘strempe’ (to the left) as nominal, but ‘pluig’, ‘krei’, and ‘drauf’ (to the right) verbal. This indicates that participants judged the stimuli as different with respect to word class, and this difference is significant ($\chi^2(19) = 117,1; p < .01$).

Where does this significant difference come from? In other words: did the participants indeed respond ‘nominal’ more often to the stimuli that were designed

as nominal? And did they respond at chance level to the stimuli designed as ambiguous? Table 4.2 shows the relationship between the design of the stimuli and the responses. For the stimuli designed as ambiguous, the participants slightly preferred a verbal response. The pattern for the stimuli designed as nominal clearly shows the expected asymmetric pattern: the subjects categorize almost 80% of the nominally designed stimuli as nominal stems ($\chi^2(1) = 102.0$; $p < .001$). For the stimuli designed as ambiguous the difference was also significant, although less convincingly ($\chi^2(1) = 6.4$; $p = .025$). Since 11 items were designed as ‘nominal’, subjects could answer ‘noun’ 11 times for the items of that design. On average, subjects provided the answer ‘noun’ 8.64 times (range 5-11, $SD = 1.97$) and the answer ‘verb’ 2.32 times (range 0-7, $SD = 2.02$). There was variation across subjects: 3 subjects gave the answer ‘noun’ only 5 times, 3 subjects 6 times, and 1 subject 7 times; the other 21 subjects answered ‘noun’ 8 times or more. The results show a clear preference of the participants for a nominal categorization of nonsense words that were designed as phonological nouns and a weaker preference for verbal categorization of nonsense words that were designed as ambiguous.

Table 4.2. Division of responses over stimulus designs in raw numbers (and percentages) in the phonology experiment with Dutch adults.

	Noun	Verb
Nominal	242 (79%)	65 (21%)
Ambiguous	105 (42%)	145 (58%)

The principles that were used to design stimuli as nominal did seem to influence participants to categorize stimuli as nominal stems. There were five different types of nominal stimuli, each corresponding to one of the generalizations found by Trommelen: bi-syllabic, stimuli ending in a long vowel, stimuli with super heavy rhymes, stimuli ending in a schwa, and stimuli ending in a schwa followed by the labial nasal [m] (see Table 4.1). In Table 4.3 the scores for the stimuli grouped in the five types are listed.

Four design principles triggered the participants to judge the corresponding stimuli as nominal in more than 80% of the cases. The exception was the principle of ‘more than super heavy’ rhymes, which resulted in categorization as nominal in only 55% of the cases. As shown above, a statistically significant difference was found in response patterns for all stimuli designed as phonological nouns. A one-way ANOVA of response \times design principle shows a significant effect of design principle on the responses ($F(5,19) = 13.3$, $p < .001$). Post hoc comparisons show

that the response pattern for the stimuli based on four of the five principles differs significantly from the response pattern on stimuli designed as ambiguous (Tukey's HSD procedure). Only the principle of heavy rhyme does not cause a significant difference and hence does not contribute to the overall significant effect.

Table 4.3. Division of responses over design principles in raw numbers (and percentages) in the phonology experiment with Dutch adults.

	Noun	Verb
bi-syllabic	48 (85 %)	8 (15 %)
final long vowel	68 (83 %)	14 (17 %)
more than super heavy rhyme	31 (55 %)	25 (45 %)
final schwa	49 (88 %)	7 (12 %)
final schwa + nasal	46 (82 %)	10 (18 %)

4.2.4. Conclusion

Of the five phonological principles presented by Trommelen, four principles do indeed provide enough cues for adult Dutch speakers to categorize stems as nominal. The results of this experimental study show that adult speakers of Dutch are able to make use of phonological cues in the discrimination of nouns and verbs. This result supports the idea that children could use such phonological properties in the process of categorization. Of course, whether this is indeed the case can only be established on the basis of experimental results from children.

4.3. Category-indicative co-occurrence patterns: a study of Dutch input

As shown in the previous section phonology is a possible categorization cue for children. The distribution of words and morphemes in a sentence is possibly also a good indicator of category membership from very early on. Because they are determined by phonological, semantic, and syntactic restrictions, the co-occurrence patterns of words and morphemes in a language are far from random. Maratsos and Chalkley (1980) presented a theory according to which children construct syntactic categories on the basis of the statistical distribution patterns of words. They proposed that children keep track of the co-occurrence patterns of all words and affixes in the ambient language, and form groups of words that have similar or identical distributional properties in a sentence. These groups of words then correspond to syntactic categories. After critical comments from Pinker (1984),

Maratsos narrowed down his proposal to verbs. Maratsos (1990) suggested that, whereas an object meaning might be the best ‘central binder’ for the category of nouns, co-occurrence patterns are still the best ‘central binder’ for the category of verbs. One of the problems Pinker (1984) indicated was: how does the child know which information it has to pay attention to in performing the co-occurrence analyses? Pinker illustrated the problem as follows: the child could assume on the basis of the utterances *John eats meat*, *John eats slowly*, and *the meat is good* that *the slowly is good* is a grammatical English sentence, which it is not. Maratsos (1990) agreed with this criticism, conceding that the ‘unbiased inductive processor’ proposed in his earlier article makes it impossible to pick the right level of analysis for nouns. However, he maintained that the grammatical words preceding and following verbs should function as cues for categorization.

Brown (1957) was the first to show that children are actually able to use the morpho-syntactic environment in which a nonsense word is presented to them to infer its possible category. He showed 3- to 5-year-old children a picture of hands kneading a confetti-like material in a bowl, accompanied by a nonsense word description of the scene as either *sibbing* or *a sib*. The children who had heard the verbal form *sibbing* understood the nonsense word *sib* as referring to the action of kneading (i.e., they assigned it a verbal meaning), whereas the children who had heard the nominal form *a sib* thought the word referred to the bowl (i.e., they assigned it a nominal meaning). Children could infer the possible categories of the nonsense words on the basis of their distributional environment. The presence of the *-ing* ending led them to categorize *sib* as a word referring to an action, whereas the presence of the determiner *a* led them to categorize it as a word referring to an object. This study can be seen as evidence that morpho-syntactic co-occurrence information is accessible to 3-5 year-old children and that they can use this information to make inferences about properties of the nonsense words.

With the development of more sophisticated methods for testing younger children, it has become clear that children are able to segment familiar words from the speech stream by 8 months (see Jusczyk & Aslin, 1995 for English; Höhle & Weissenborn, 2003 for German). If children can segment words, the co-occurrence patterns of words can become available to them.

Transitional probabilities between syllables have also been explored in recent studies as possible indicators of word boundaries. If infants can identify word boundaries, they may be able to determine the important distributional environments indicative of categories. An early study of this kind of statistical learning by Saffran, Aslin & Newport (1996) shows that 8-month-old English-learning children are able to segment words from the speech stream solely on the basis of transitional

probabilities. The statistical properties of phonological forms help infants to detect word boundaries and so to detect the co-occurrence patterns of words. Subsequent studies show that by the age of 18 months English infants can detect not only words but also frequently-occurring relationships between two words or morphemes that are separated by other words (e.g., the relationship between auxiliary *is* and progressive ending *-ing* in English) (Santelmann & Jusczyk, 1998). German children are able to do the same around 19 months of age (Höhle, Schmitz, Santelmann, & Weissenborn, 2006). These long-distance relationships between two words in a sentence are especially well perceived by children if the intervening material is highly variable (Gómez, 2002).

These findings have important implications for category acquisition, according to Mintz (2003). He proposed that the long-distance relationships between frequently and invariably co-occurring items ('frequent frames') provide the crucial contexts children need for early categorization. Earlier proposals based on the relevance of co-occurring words mainly focused on 'bigrams', i.e., a target word X with either the preceding or the following word as a cue (e.g., Cartwright & Brent, 1997; Redington, Chater, & Finch, 1998; Mintz, Newport, & Bever, 2002). The advantage of focusing on the relationship of the to-be-categorized word with the combination of both the preceding and the following word, according to Mintz, is that it results in more accurate categories than the bigram analyses provided. He showed for English that such a mechanism would result in very reliable links between distribution and category, and proposed that this mechanism can be used in language acquisition in general.

I have investigated this proposal for Dutch. If local co-occurrence contexts such as frequent frames are indeed a general category learning mechanism, the links between the frequent frames and category have to be reliable in all languages. Mintz (2003) looked at the input to English-learning children. Mintz's input study of English will be reported first to provide more detail about his frequent frame proposal. This study was also replicated for Dutch, which will be reported in §4.3.2. The results will show which co-occurrence information might be indicative of category in Dutch.

4.3.1. Mintz's frequent frame proposal

Mintz (2003) suggests that the child only needs to focus on the local context of a lexical item to categorize it correctly. The crucial local context under consideration is that of frequent frames. A frequent frame is defined as a frequently occurring combination of two words with exactly one word position (X) intervening, e.g., *you X it* (X = *have, like, show, etc.*). Mintz shows with an English input study that the set

of words $X \{X_1, X_2, \dots, X_n\}$ within a certain frequent frame forms an accurate category compared to the adult syntactic category.

Mintz took all the adult input utterances from six English child language corpora in the CHILDES system in which the children were younger than 2;6. Table 4.4 presents general information about these corpora. Analyses were performed on both tokens and types, because a token-based analysis reflects the frequency of words and a type-analysis reflects the diversity of words. If these two measures lead to significantly different categorization results, either the frequency of a word's occurrence or the number of different types of words is important for the frequent frame mechanism to work. In §4.3.2 I will show that the difference between tokens and types is more relevant for Dutch than it is for English.

Table 4.4. Session ranges for analyzed English input corpora (alphabetically); number of utterances, number of tokens and types categorized by 45 most frequent frames (Mintz, 2003: 96).

Child	CHILDES sessions	# of utterances	Tokens categorized	Types categorized
Anne	anne01a- anne23b	26199	4389	405
Aran	aran01a- aran20b	20857	5628	620
Eve	eve01-eve20	14922	3513	400
Naomi	n01-n58	6950	1617	297
Nina	nina01-nina23	14417	6265	469
Peter	peter01- peter12	19846	5690	446
Mean		17198	4517	439.5

From the 17,198 input utterances Mintz extracted all trigrams, i.e., three-word sequences. For example, six trigrams can be extracted from the utterance *do you want to give it to me*: (1) *do you want*, (2) *you want to*, (3) *want to give*, (4) *to give it*, (5) *give it to*, and (6) *it to me*. The middle word of each trigram was then replaced by a variable X , resulting in the frames of co-occurring words with exactly one word position intervening. The second trigram of the example above would result in the frame *you X to*. All frames (i.e., instances of $a X b$ where X is variable) in the input speech were counted. The frame *you X to* thus occurs not only in an utterance with *you want to*, but also in utterances containing the trigrams *you try to* or *you also to*.

A subset of 45 most frequently occurring frames was selected for each corpus. For each of these 45 most frequent frames, all intervening words were listed, resulting in frame-based categories. The frame-based category resulting from the frequent frame *you X to* consists of words such as *want*, *try*, and *also*. These frame-based categories were further analyzed to see how they are related to the adult lexical categories of the words occurring in them.

Each type in a frame-based category was labeled for its actual syntactic category in English (verb, auxiliary, copula, noun, pronoun, adjective, preposition, adverb, determiner, wh-word, “not”, conjunction, interjection). For example, in the frame *you X to*, *want* was labeled as a verb, *also* as an adverb, etcetera. To calculate the accuracy of the frame-based categories, the category labels of all possible pairs of intervening items were compared to see if they counted as a ‘hit’ or a ‘false alarm’. A hit was counted for two items with the same grammatical category label, and a false alarm for two items with different labels. Accuracy is computed by the formula in (4).

$$(4) \text{ Accuracy} = \frac{\text{Hits}}{(\text{Hits} + \text{False Alarms})}$$

The total number of hits (i.e., instance of two identical category labels) in a frame-based category is divided by the number of hits plus false alarms (i.e., instance of two different category labels). If all types within a frame-based category were from the same syntactic category, the type accuracy would be 1, since then the number of false alarms is 0; the higher the accuracy of a frame, the more consistent the frame-based category. Take, for example, the previously-mentioned frame *you X to* in which 2 verb types (*want* and *try*), and 1 adverb type (*also*) occur. The category labels of the types are now compared to each other and each comparison renders either a ‘hit’ or a ‘false alarm’. If the types *want* and *try* are compared with each other, they result in a hit, because both are labeled as verb. If *want* and *also* are compared with each other, they result in a false alarm, because they have different category labels: verb and adverb. This example results in 1 hit (comparison of *want* and *try*), and 2 false alarms (comparisons of *want* and *also*, and of *try* and *also*). The resulting accuracy of the category based on this frame would be the total number of hits divided by the total number of hits + false alarms: 1 divided by 3 = 0.33, a relatively low accuracy.

Mintz (2003) performed two different kinds of accuracy analyses. In his *expanded* analysis all assigned category labels were taken as separate categories, whereas in his *standard* analysis verbs, auxiliaries and copulas were counted as a

single category, as were nouns and pronouns. Since the number of possible false alarms with fewer categories is lower, the standard analysis always results in the same or higher accuracy measures than the expanded analysis. The mean token accuracy across all corpora was 0.98 in the standard analysis and 0.91 in the expanded. Mean type accuracy was 0.93 in the standard analysis and 0.91 in the expanded analysis. The average accuracy of the categories in the six corpora taken separately ranged from 0.80-0.98.

The most likely explanation for these high accuracy measures is that the specific distributional contexts of frequent frames yield reliable categories. To test this, Mintz calculated the accuracy of random categories for each corpus. The random categories consisted of the words from the original frame-based categories but now randomly divided across the categories. So all tokens that were categorized by the frequent frames (see Table 4.4) were randomly redistributed over 45 new, similarly sized categories. The scores of the resulting categories provide an indication of how high the accuracy is if all tokens within the frame-based categories are randomized and new categories are compiled of equal size and number. The only difference between these random categories and the frame-based categories is the frequent frame information. The average random scores for English varied between 0.23 and 0.55. Since these random measures differed significantly from the measures of the earlier analyses, Mintz concluded that frequent frames contribute important information for categorization.

All the scores of the six corpora of input to the English-speaking children Mintz analyzed are shown in Table 4.5. Each row in the table represents one of the corpora from CHILDES, listed in alphabetical order. For each corpus, the average accuracy scores in all analyses are provided. The second and third columns, for example, provide the accuracy of the categories of tokens in the standard analysis in both the frame-based condition (A for 'analyzed') and the baseline condition (R for 'random'). The accuracy scores of the frame-based categories are significantly higher than baseline in all conditions. The difference between tokens and types was only significant in the standard analysis. The frequency with which a word type appears thus does not play an important role in the frame-based categories of English.

Mintz (2003) concluded that the specific distributional context of frequent frames forms a highly reliable bootstrap for categories in English. Moreover, he proposed that using distributional information for categorization could be a generally valid mechanism in child language acquisition. He acknowledged that some typological differences might affect the success of such distributional mechanisms. However, he suggested that languages with freer word order may still

show enough consistency in distributional patterns, for example in terms of frequently co-occurring morphemes rather than words. In the following section, the success of this proposal will be investigated for Dutch, a language typologically related to English. The outcomes of the study of frequently co-occurring words in the Dutch input will be reported.

Table 4.5. Token and type accuracy for standard and expanded analysis (A), including baseline accuracy of random categories (R) for all English corpora (Mintz, 2003: 100).

Corpus	Standard Analysis				Expanded Analysis			
	Tokens		Types		Tokens		Types	
	A	R	A	R	A	R	A	R
Anne	0.98	0.37	0.94	0.41	0.84	0.24	0.90	0.31
Aran	0.97	0.44	0.89	0.42	0.80	0.23	0.87	0.33
Eve	0.98	0.51	0.92	0.50	0.91	0.25	0.89	0.40
Naomi	0.97	0.48	0.94	0.49	0.96	0.30	0.93	0.41
Nina	0.98	0.48	0.95	0.46	0.98	0.29	0.94	0.36
Peter	0.98	0.49	0.96	0.55	0.97	0.32	0.95	0.49
Mean	0.98	0.46	0.93	0.47	0.91	0.27	0.91	0.38

4.3.2. Frequent frames in Dutch input

To establish whether frequent frames are available in the input from other languages than English, the input from Dutch child language corpora was studied, in which the method developed by Mintz (2003) was followed very closely.¹⁶ I analyzed the input speech to the same four Dutch children, which was available in CHILDES, as studied in the longitudinal production study reported in §3.3. They were younger than 2;6. General information about these files is presented in Table 4.6. Mintz (2003) found similar frequent frames and accuracy numbers for each of the six child corpora he examined and the number of utterances in the first four corpora he examined is comparable to the four Dutch corpora examined here. Although the total number of corpora and utterances examined by Mintz was greater than in the data available for this analysis, this is not of major consequence.

As with the English corpora, all frames in the input speech were counted and the 45 most frequent frames were selected for each corpus. The fourth and fifth column

¹⁶ This study was also reported in Erkelens (2008).

of Table 4.6 indicate the number of tokens and types that are contained within the 45 most frequent frames of the corpora. For these 45 most frequent frames, all intervening words were listed, resulting in frame-based categories. These frame-based categories were further analyzed to see how they are related to the syntactic categories of the words occurring in them. For Dutch, I used slightly different labels for these categories than Mintz did for English. Since the Dutch negative particle *niet* ‘not’, unlike its English counterpart, has the same distributional properties as all other Dutch adverbs, it was categorized as an adverb, and not as a separate category as Mintz created for “not”. A separate category for proper names was included for two reasons. They occurred very frequently within the Dutch frame-based categories and in the production data (§3.3) proper names were used differently by children than by the adults. The categories used in this Dutch input study are thus verb, auxiliary, copula, noun, pronoun, proper name, adjective, preposition, adverb, determiner, wh-word, conjunction, and interjection. All word types that occurred in the frame-based categories were assigned to one of these categories. For words in Dutch that can occur in multiple categories, the corpora were checked to see in which category the word was used in the specific frame. Just as in Mintz (2003), a standard and an expanded analysis were performed. In the expanded analysis all 13 assigned category labels were taken as separate categories, whereas in the standard analysis verbs, auxiliaries and copulas formed one category, as did nouns, pronouns, and proper names, leaving nine categories. Accuracy scores were computed in the same way as Mintz (see §4.3.1).

Table 4.6. Session ranges for analyzed Dutch input corpora (alphabetically); number of utterances, number of tokens and types categorized by 45 most frequent frames.

Child	CHILDES sessions	# of utterances	Tokens categorized	Types categorized
Daan	daa10821- daa20625	13301	2569	324
Laura	laura01- laura22	8811	1948	291
Matthijs	mat11013- mat20619	16813	2927	319
Sarah	sarah01- sarah19	10710	2186	296
Mean		12409	2407	308

Results for the accuracy analyses in the Dutch corpora were quite different from those of the English corpora. The mean token accuracy across all corpora was 0.71 in the standard analysis (English: 0.98) and 0.56 in the expanded analysis (English: 0.91). Mean type accuracy was 0.59 in the standard analysis (English: 0.93) and 0.40 in the expanded analysis (English: 0.91). The range of average accuracy scores for the separate corpora was 0.38-0.76 (English: 0.80-0.98). Although Mintz (2003) does not report the range of accuracy measures over the frames, such a range provides insight into the contribution of each frame to the average accuracy scores. If the range over frames is limited, each frame is a reliable categorizer, whereas large ranges indicate a high variability of informational value over frames. For Dutch, the accuracy scores of the type-based analyses ranged from 0.00-1.00 and those of the token-based analyses from 0.18-1.00. The Dutch frequent frames vary enormously in their categorization power.

The Dutch frequent frame *ik X het* 'I X it' provides a good example of the difference in accuracy scores between Dutch and English. The frame-based category of its English counterpart *I X it* consists solely of verbs in the input to English Peter (Mintz, 2003). However, the frame-based category of the Dutch frame *ik X het* in the input to Dutch Matthijs contains not only verbs, but also the preposition *aan* (which is often used in the construction *aan het X-en* with a meaning similar to the English progressive) and the adverbial particle *dan* 'then'. Quite a number of these adverbial particles seem to disturb the co-occurrence patterns across frequent frames in Dutch. It is possible that this language-specific property of Dutch makes it difficult for children to trace the dependency between the framing words (see the discussion later on in §6.3). However, it is not clear whether there is an overall major typological difference causing the lower accuracy measures.

Just as in Mintz's study, I compiled random categories in this study in which the tokens of the frame-based categories were randomly distributed across the 45 frequent frames. The accuracy measures of these random categories serve as a baseline for the informativeness of word distribution in Dutch. The Dutch results for each child are presented in Table 4.7 and a comparison of the mean accuracy results of all six English and four Dutch corpora is presented in Table 4.8. Both the numbers for the analyses ('A') and the randomly compiled categories ('R') are provided.

Statistical analysis of the accuracy measures of both English and Dutch allows us to compare the informativeness of frequent frames in the two languages. As reported earlier by Mintz (2003), the English accuracy scores were significantly higher than baseline in both the standard analysis and the expanded analysis. The same is true for the Dutch accuracy scores in both the standard analysis (tokens: $t(3) = 24.6$, $p <$

.0001; types: $t(3) = 19.3$, $p < .0001$) and in the expanded analysis (tokens: $t(3) = 30.6$, $p < .0001$; types: $t(3) = 20.6$, $p < .0001$). The differences between tokens and types were significant in the standard analysis both for English ($t(5) = 5.8$, $p < 0.01$) and for Dutch ($t(3) = 19.5$, $p < .0001$). In the expanded analysis, the token-type difference is only significant for Dutch ($t(3) = 21.7$, $p < .0001$). This means that for Dutch, the accuracy is higher when the frequency of the items is taken into account. The type-token ratio in Dutch is somewhat higher than in English, which causes the difference between the two languages here. On the basis of the fact that the accuracy measures of the frame-based categories in both English and Dutch are significantly higher than baseline, frequent frames in Dutch are potentially informative with respect to the category of intervening items.

Table 4.7. Token and type accuracy for standard and expanded analysis (A), including baseline accuracy of random categories (R) for analyzed Dutch corpora.

Corpus	Standard Analysis				Expanded Analysis			
	Tokens		Types		Tokens		Types	
	A	R	A	R	A	R	A	R
Daan	0.69	0.39	0.57	0.34	0.53	0.16	0.38	0.16
Laura	0.69	0.33	0.58	0.29	0.56	0.13	0.41	0.14
Matthijs	0.76	0.43	0.64	0.38	0.58	0.18	0.41	0.18
Sarah	0.69	0.38	0.55	0.31	0.58	0.16	0.40	0.14
Mean	0.71	0.38	0.58	0.33	0.56	0.16	0.40	0.16

Table 4.8. Average accuracy of frame-based categories in English and Dutch for standard and expanded analysis (A), including baseline accuracies of random categories (R).

Language	Standard analysis				Expanded analysis			
	<i>Tokens</i>		<i>Types</i>		<i>Tokens</i>		<i>Types</i>	
	A	R	A	R	A	R	A	R
English	0.98	0.46	0.93	0.47	0.91	0.27	0.91	0.38
Dutch	0.71	0.38	0.58	0.33	0.56	0.16	0.40	0.16

However, the accuracy scores are higher for English than for Dutch. These differences between the two languages are significant in all possible conditions in the standard analysis (tokens analysis: $t(8) = 19.1$, $p < .01$; tokens random: $t(8) =$

2.6, $p < .05$; types analysis: $t(8) = 17.5$, $p < .0001$; types random: $t(8) = 4.6$, $p < .01$) and in the expanded analysis (tokens analysis: $t(8) = 8.4$, $p < .0001$; tokens random: $t(8) = 5.6$, $p < .01$; types analysis: $t(8) = 30.2$, $p < .0001$; types random: $t(8) = 6.7$, $p < .01$). The accuracy measures for English are higher than those for Dutch. However, the baseline measures for English are also significantly higher than those for Dutch in all conditions (standard tokens: $t(8) = 2.6$, $p < .05$; standard types: $t(8) = 4.6$, $p < .01$; expanded tokens: $t(8) = 5.6$, $p < .01$; expanded types: $t(8) = 6.7$, $p < .001$). So, although frequent frames are informative for both languages, the higher accuracy measures for English indicate that frequent frames are more informative about category membership in English than in Dutch.

4.3.3. Conclusion

Co-occurrence patterns are indicative of the category of words both in English and in Dutch. However, the specific local context of frequent frames as operationalized by Mintz (2003) provides more accurate categories in English than in Dutch. As Mintz suggested, the granularity of the frequent frame may differ across languages. The word level may be too coarse a unit in Dutch. Dutch has more morphology on verbs and nouns than English. Therefore, it seems worthwhile to consider the level of granularity that is most informative for Dutch categories. The attested differences between Dutch and English with respect to frequent word frames may be a consequence of the available material in the two languages. Suppose that the learning mechanism used by children is to search for the most frequent non-adjacent elements (i.e., frames). If this search starts from the smallest frame possible (the most local context), then Dutch children may already have a large number of morpheme frames at their disposal that provide them with morpheme frame-based categories before they ever arrive at the word frames investigated in this input study.

In order to test this suggestion, a method is needed to assess young children's use of frames for categorization. Unlike the use of phonology for categorization by young infants, the use of frames has been investigated earlier. In the next section these studies will be evaluated to determine whether the method used there, perception experiments, would be suitable for testing whether Dutch children use frequent frames defined in terms of either words or morphemes.

4.4. Perception experiments as a method to test early categorization

Perception data allow us to study linguistic development before children actually start to talk. Over the last decades the methods of conducting perception experiments

have improved enormously; there are now suitable methods for the observation of specific aspects of linguistic comprehension in very young children. In a recent overview of research on infant speech perception, Gerken & Aslin (2005) show that techniques such as High Amplitude Sucking (HAS, e.g., Jusczyk, Rosner, Cutting, Foard, & Smith, 1977) and the Head-turn Preference Procedure (HPP, Hirsh Pasek et al., 1987; Kemler Nelson et al., 1995) have provided many insights into the phonological and lexical development of infants between 6 and 12 months old. These same techniques are currently used increasingly often to investigate the morphological and syntactic development of infants. Before reviewing perception methods as a means of studying syntactic development and, more specifically, verbs and nouns, the interpretation of data from perception experiments will be considered in general.

4.4.1. General considerations for interpreting perception data

The perception of language can be tested only indirectly, by observing children's behavior. Speech stimuli are presented to infants while their behavioral response (e.g., sucking, looking) is measured. A dependent measure that is often used in perception experiments with young children is the duration of the behavioral response. It has to be assumed that this response (i.e., the duration of a look) is a measure of the child's listening time to the stimulus. The growing body of evidence that head-turn experiments provide in young children confirms the likelihood of this assumption. If children differ significantly in the time they spend listening to stimuli in two different conditions, this indicates sensitivity to the variable on which the two conditions differ. Research questions that can be answered with such experiments need to focus on children's sensitivity to a certain property of language. Perception experiments cannot be used to answer questions about the grammar that underlies children's ability to distinguish these stimuli. For example, the question whether the child's category of verb is defined by the presence of a specifier position, as Baker (2003) proposes, cannot be tested with a perception experiment because it is impossible to design two sets of stimuli that differ only on this particular property. However, a very carefully designed experiment can be used as a possible window on children's sensitivity to linguistic patterns.

By controlling for factors that are irrelevant to the research question and manipulating the factors that are relevant, different details of language can be investigated separately. Perception experiments thus can provide evidence for theories about the properties of the input that play a role in the identification of categories by infants. Since the design of the stimuli determines the interpretation of perception data to a considerable extent, phonological, morphological, and syntactic

factors that might disturb the picture must be controlled for. Using nonsense words instead of real words can also control for lexical factors. In this section some of the perception studies on syntactic development and category acquisition will be reviewed to show that perception experiments provide a good method for testing which co-occurrence patterns Dutch infants use for early syntactic categorization.

4.4.2. Perception of syntactic structure

Although perception techniques were first used to study phonological and lexical development, more recent experiments also address syntactic development. The crucial difference between sounds and words on the one hand and syntactic structure on the other hand is that syntactic structure entails relationships between two or more units in a sentence. For example, languages differ in the order in which heads and complements are expressed in a sentence. This difference is traditionally called the OV/VO parameter (e.g., Neeleman & Weerman, 1997). Acquiring the directional relationship between heads and complements in a sentence is in essence a syntactic rather than a lexical development.¹⁷ In a perception study using the HAS procedure Christophe, Nespoulet, Guasti, Dupoux, and Van Ooyen (1997) showed that infants as young as 3 months distinguish the prosodic patterns of OV and VO languages. OV languages systematically stress the right part of a phonological phrase, whereas VO languages systematically stress the left part. The infants Christophe et al. (1997) tested were sensitive to these differences. They propose that children use the prosodic structure to bootstrap the place of the head in a phrase. As the authors acknowledged, this finding does not imply that children have ‘set’ the parameter for their language. However, it does tell us that very young infants are sensitive to input characteristics related to syntactic phenomena. Even before they segment words (the earliest age for which word segmentation is reported is 7.5 months: Jusczyk & Aslin, 1995), they are sensitive to prosodic characteristics indicative of syntactic structure. This means that precursors of syntactic development may be present at birth, or even before.

There are, of course, syntactic dependencies that are not adjacent, such as agreement relationships. For example, there is always at least a verbal stem – and often additional linguistic material – between the English auxiliary *is* and the progressive ending *-ing*. Using the HPP technique, Santelmann & Jusczyk (1998) show that at 18 months infants are sensitive to the syntactic dependency between the auxiliary *is* and the progressive ending, whereas they are not sensitive to an

¹⁷ Some researchers state that syntactic relationships like head-complement are also learned lexically first. This does not change the assumption that the relationship between heads and complements is a syntactic one.

unnatural dependency between the auxiliary *can* and the progressive ending. They are still sensitive to the dependency between *is* and *-ing* if as many as three syllables are inserted between them, but not four or more. If we compare these results to what we know about children's production data, it is striking that children can already trace these syntactic dependencies long before they are able to produce them. The dependencies tested in these studies are investigated on the basis of concrete linguistic input (prosody and real words). The children's sensitivity to these syntactic phenomena could stem from learned morpho-syntactic properties of the adult language such as basic word order and verbal inflection. An equally plausible explanation, however, is that they are sensitive to frequency in the linguistic input. In English, *is* and *-ing* are likely to occur more frequently together in a sentence than *can* and *-ing*. The results would then only indicate that 18-month-old children are able to detect frequently occurring invariable non-adjacent morphemes in their input.

Results from artificial grammar studies in infants support the former explanation, i.e., that 18-month-olds have indeed acquired the basic word order and verbal inflection of English. Gómez & Gerken (1999) trained 12-month-old infants with stimuli generated by an artificial grammar. Since these children had never heard sentences from this grammar before, they could not already know the frequency of certain co-occurring words. The only possible way for the children to know things about the grammar was to learn them from the few stimuli presented to them in training. The HPP experiments by Gómez and Gerken (1999) show that these one-year-olds were able to distinguish grammatical from ungrammatical word orders, even if other words were used than those presented in training. Children use the co-occurrence information from concrete linguistic stimuli to make abstractions and to learn word order rules. These outcomes make a stronger case for HPP experiments as a means to test children's knowledge of grammar. However, in experiments with a real grammar (and stimuli), the interpretation that previous knowledge of the grammar is decisive for performance cannot be excluded.

On the basis of these studies of syntactic development it can be concluded that perception experiments are a promising method to answer questions about the mechanisms that are at work in early syntactic development.

4.4.3. Perception of verbs versus nouns

The relevant question for purposes of the current research is of course whether perception experiments are suitable to test the acquisition of verbs and nouns. As indicated in §1.1, different kinds of properties (morphological, syntactic, semantic) relate in different ways to these categories. Some of these properties are phonetically

perceptible in a linguistic utterance (e.g., the distribution of morphemes and words in a sentence), whereas other properties are not (e.g., the meanings of the words). In perception techniques such as the HPP, phonetically perceptible properties play a crucial role in testing, since the stimuli are presented auditorily. As a consequence, all perception studies on categorization focus on the relevant phonetically perceptible linguistic context that is needed to arrive at categorization of lexical items (e.g., their distribution) and not on the properties that are not directly perceptible (e.g., their meaning and syntactic features).

As reported in §4.3, scholars have proposed that function words that surround lexical items with especially high frequency play an important role in learning to categorize these lexical items. Theories of the relevance of co-occurrence patterns for the identification of categories have been tested in various languages. In an HPP experiment with German children, Höhle and her colleagues (Höhle, Weissenborn, Kiefer, Schulz, & Schmitz, 2004) tested the role of function words such as determiners and pronouns in the categorization of nonsense words. They trained children on sentences with nonsense words (*glamm* and *pronk*) modeled either as nouns (preceded by a determiner) or as verbs (preceded or followed by a pronoun). Examples of the training sentences are: *zwischen den Bäumen pronk¹⁸ er nicht so oft* ‘he did not pronk so often between the trees’ and *dieses Glamm war ganz bunt und wunderschön* ‘This glamm was entirely colorful and beautiful’. In the test phase, children were presented with the same nonsense words preceded by either the indefinite determiner *ein* ‘a’, or the third person pronoun *sie* ‘she’ (*ein glamm*, **sie glamm*, **ein pronk*, *sie pronk*). The children’s listening times to the combinations consistent with the training phase (*ein glamm* if *glamm* was a noun in training, *sie pronk* if *pronk* was a verb in training) were compared to the children’s listening times to the ungrammatical, inconsistent combinations (**sie glamm* if *glamm* was a noun in training, **ein pronk* if *pronk* was a verb in training). The 12-month-old infants did not show a difference in listening times, but the 16-month-olds did: they listened longer to **sie glamm* than to *ein glamm* if *glamm* was a noun in training.

The conclusion that the researchers draw from this experiment is that 16-month-old German children are able to categorize the nonsense words as nouns on the basis of the determiners. It is questionable, however, whether this experiment actually shows that children have a grammatical representation of nouns. Children were familiarized with sentences in which the phonetically perceivable distributional cues

¹⁸ Note that the 3rd person singular simple past in German regularly receives an inflectional ending *-te*. Irregular verbs do not receive an ending, but only undergo vowel change and this is what the researchers tried to model here. The word form *pronk* has a phonological make-up similar to that of the past tense of some existing irregular verbs in German (e.g., *trink-/trank-* ‘drink / drank’).

pointed to the category of the nonsense words. If children use the distributional cues to categorize the nonsense words, it can be said that they have categorized the nonsense words together based on the distributional property '[determiner] _', which is indicative of the nominal category in German. The fact that they are able to group new words with other words that follow a determiner in German does not necessarily imply that they have a category of nouns with any properties that go beyond that of following a determiner. It is possible that these children have a category of determiner-following words that also includes adjectives (e.g., in a sentence such as *der rote Glamm* 'the red glamm', the adjective *rote* obeys the criterion of the '[determiner] _' category). What this experiment clearly does show is that 16-month-old German infants use determiners to identify this construction.

Mintz (2006) conducted a similar experiment with English-speaking children to test his proposal about the role of frequent frames in learning to categorize (§4.3.1). This experiment showed that it is possible to test the use of this cue by infants, which is especially relevant for the present study on Dutch. He taught English-speaking children four nonsense words (*deeg*, *lonk*, *gorp*, and *bist*), embedded in the specific distributional contexts of frequent frames. In a familiarization phase, 12-month-old children heard two of the nonsense words in four frames (embedded in longer utterances) that host verbs (*you_the*, *to_it*, *I_you*, *can_#*). The other two nonsense words were presented in four frames that host nouns (*the_in*, *your_#*, *his_on*, *a_of*). Every nonsense word was thus presented in four different frames, all either nominal or verbal. A word familiarized in nominal frames is a nonsense noun, and a word familiarized in verbal frames is a nonsense verb. In the test phase children heard the same nonsense words in either a similar category frame (i.e., a nonsense verb in another verb frame) or in the other, inconsistent frame (i.e., a nonsense verb in a new noun frame). For example, if the nonsense verbs were *deeg* and *lonk* and the nonsense nouns *gorp* and *bist*, a child heard in the familiarization phase 'can you *deeg* the room', 'she wants to *lonk* it', 'I see the *gorp* in the room', and 'here's a *bist* of a dog'. For this child, consistent sentences in the test phase would be 'can you *lonk* the room' and 'I see the *bist* in the room' and inconsistent sentences would be 'she wants to *gorp* it' and 'here's a *deeg* of a dog'. Mintz compared the listening times to the consistent and inconsistent sentences. For sentences with a verb frame, the 12-month-old children listened longer to the inconsistent sentences than to the consistent ones. This means that they were sensitive to the inconsistent pairing of nonsense nouns with verbal frequent frames. For the sentences with noun frames, he found no differences in listening times. To illustrate with our examples children thus listened significantly longer to 'she wants to *gorp* it' (*gorp* was familiarized in a noun frame) than to 'she wants to *deeg* it'

(*deeg* was familiarized in a verb frame) but they did not listen longer to '*here's a deeg of a dog*' (*deeg* was familiarized in a verb frame) than to '*here's a bist of a dog*' (*bist* was familiarized in a noun frame). The fact that the children discriminated between the consistent and inconsistent verb-frame sentences indicates that they did use the distributional contexts (i.e., frequent frames) in the training phase to categorize the new words. They had never heard the nonsense words used in the test phase frames before, but they still differentiated between the verbal and nominal frames, at least for the nonsense words modeled as verbs. Mintz suggests that differences of frequency in the input explain why the infants did not distinguish between test conditions for the nonsense words modeled as nouns. Whether these 12-month-old English-learning children also have a grammatical representation of the category verb cannot be assessed with this kind of experiment. However, this experiment does establish that these English-learning infants used frequent frames for categorization.

4.4.4. Conclusion

Perception experiments can be used to study the categorization abilities of pre-verbal infants. The results of previous experiments primarily provide information about the co-occurrence properties of the input children use in the process of categorization. Such co-occurrence patterns can be modeled in detail and irrelevant factors can be controlled for. If designed properly, perception studies thus provide informative data on the mechanisms that are at work in the process of category learning. Especially Mintz's (2006) experiment suggests that an HPP experiment could be a good method for testing whether Dutch infants use frequent frames for categorization. The next chapter reports two HPP experiments that investigate the use of frequent frames by Dutch infants.

It is not clear that the findings from perception studies on German and English can be automatically applied to other languages. There are cross-linguistic differences in the age of production of determiners (see Rozendaal & Baker, 2008 and references therein), which might mean that there are also cross-linguistic differences in the age of perception. French children are faster at producing determiners than English children, and English children are faster than Dutch children. At least in part, this is a consequence of the use of determiners in the input of these three languages. Rozendaal and Baker's study of the input to French, English, and Dutch children reveals not only that Dutch has fewer obligatory contexts for the production of determiners, but also that Dutch adults¹⁹ omit

¹⁹ Two of the input corpora analyzed by Baker & Rozendaal (2008) were also used for the input study reported in §4.3.2 here, namely those of Matthijs and Sarah.

determiners in obligatory contexts in their speech to children more often than English and French adults do. As a consequence, Dutch children probably have a harder time detecting those elements in the input and using them in early categorization. Although Höhle and Weissenborn (2003) have shown that the perception of function words in German seems to be parallel to that in English, it cannot be assumed that co-occurrence cues are accessible to Dutch children as early as they are to English children. It is a question for further research to determine whether there are differences across languages in the usefulness and accessibility of co-occurrence properties as indicators of category membership.

A clearly defined co-occurrence pattern such as a 'frequent frame' can be incorporated into stimuli presented to children in a perception experiment. However, the stimuli have to be modeled carefully in such a way that the co-occurrence information is the only information that differs between variables. As we have seen in this chapter, the phonological form of words and the syntactic structure of the sentence also provide information about the category of the word. The influence of the phonological form can be controlled for by taking word forms that are equally likely to be phonological nouns, or phonological verbs in the language (see §4.2). The influence of the syntactic structure can also be controlled for by keeping the properties of the wider syntactic environment similar in both conditions of the experiment.

4.5. Conclusion

The experimental study with Dutch adults reported in §4.2 showed that the phonological form of Dutch words is indicative of their category: Dutch adults were able to categorize nonsense stems as nouns based on their phonological make-up. To test whether children also use this cue in early categorization is more difficult. It is not possible to use the design of the reported experiment with young children. The first problem is the presentation of nonsense stems in isolation. If children hear a nonsense word without any morpho-syntactic context, the task is too complex and unnatural for them to provide reliable results. Second, children of course cannot be asked to tick a mark for verb or noun, so the method of collecting responses has to be adjusted. It is very difficult to design the categories verb and noun as answer options. One way to do this is by using a picture selection task. The method used by Cassidy & Kelly (1991) can be seen as a version of such a selection task. They used a video in which the action stood for the verb answer and the object for the noun answer, the child had to select one of the options. Such a method, however, can only be used with children of at least 2 years of age (Gerken & Shady, 1996). Since the

production studies in Chapter 3 showed that 2-year-old children are already adult-like in their categorization, a different method such as a perception experiment is needed to test whether infants use phonological properties as indicators of category at earlier stages of development.

The input study of frequent frames reported in §4.3 revealed that frequent word frames are available as indicators of category in Dutch. The resulting frame-based categories are, however, less accurate compared to the adult lexical categories than they are in English. It was therefore hypothesized that frequent morpheme frames may prove to be better indicators of category in Dutch than frequent word frames.

The method used in the perception experiments discussed in §4.4 proved to be suitable for testing categorization in pre-verbal infants. The HPP has already been employed to test the use of frequent word frames by English 12-month-olds. In principle, the method is also suitable to test the use of phonological form as category-indicative property. However, it is more logical to start out by replicating the experiments on co-occurrence patterns than to design an experiment for testing the phonology. Therefore, the use of frequent frames will be tested first. The experiments on Dutch infants' use of these frames are described in Chapter 5. The predictions for the experiments are drawn directly from the comparison of the input studies on frequent frames in English and Dutch discussed in this chapter. The studies described in this chapter thus have shown that it is possible to study categorization in younger infants by investigating their use of category-indicative input properties such as phonology and co-occurrence patterns. In the next chapter the use of the category-indicative property 'frequent frames' by Dutch infants will actually be tested.

5 Perception studies of the use of frequent frames by Dutch infants

This chapter presents the outcomes of two perception experiments with Dutch infants. These outcomes form part of the answer to the question as to which input properties play a role in learning to categorize verbs and nouns in Dutch. The input study on co-occurrence patterns reported in Chapter 4 revealed that the co-occurrence properties of frequent frames in the Dutch input differ from those in the English input. Although for both languages the co-occurrence of words is an indicator of categories, this indicator could be more helpful in English than in Dutch. The experiments in this chapter test at which structural level co-occurrence information is used by Dutch children to categorize nonsense words: that of words or morphemes. The first experiment tests whether Dutch infants aged 12 and 16 months use frequent *word frames* for categorization in a way similar to English infants. In this sense it tries to replicate Mintz' (2006) study with Dutch infants, but recall that the input study reported in §4.3 revealed that the word-level may be not the right level for accurate categorization in Dutch. So the second experiment tests whether 16-month-old infants use *morpheme frames*, which are finer-grained than word frames. After a discussion of the research questions and expected outcomes (§5.1), both experiments are described in detail (§5.2/§5.3). The chapter finishes with a conclusion and a discussion of the cross-linguistic differences between English and Dutch (§5.4).

5.1. Introduction

According to Mintz (2006), frequent frames play a role in learning to categorize. His experiment with English 12-month-olds showed that these infants do indeed use frequently co-occurring non-adjacent words to categorize intervening nonsense words. In this chapter two experiments are reported that test whether frequent frames are equally relevant in learning to categorize in Dutch. The first experiment is a close replication of Mintz (2006) and tests the use of frequent frames in terms of words (frequent word frames). The second experiment tests the use of frequent frames in terms of morphemes (frequent morpheme frames - Erkelens, Kerkhoff, & De Bree, in prep).

The input studies reported in §4.3 revealed a difference between English and Dutch with respect to the co-occurrence patterns of words. Dutch frequent word

frames turned out not to be as reliable for categorization as English frequent word frames. Whereas the average accuracy of the English frame-based categories ranges from 0.80-0.98, the Dutch accuracy rates were significantly lower, with averages ranging from 0.38-0.76. These language-specific accuracy rates are potentially problematic for the notion that frequent word frames could be an important mechanism for learning categories. However, they do not need to be problematic. First, since the Dutch accuracy rates are significantly higher than baseline, children may still be able to use the frequent word frames for categorization. Second, even if they do not use word frames, the frequent frame mechanism may work at another level of analysis, depending on the material available in the language input. Since nominal and verbal morphology is richer in Dutch than in English, the Dutch input contains more instances of the smaller frame of affixed morphemes. There is evidence that children start with a small processing window and only gradually pay attention to dependencies over a longer distance (see further discussion in §6.3, and Santelmann & Jusczyk, 1998). If we assume that the default assumption of a language-processing child is to pay attention to the smallest frequently co-occurring segmentable units, a Dutch child will find more bound morphemes than an English child. So if co-occurrence properties play a role in learning to categorize, Dutch infants might detect frequently co-occurring morpheme frames that are not frequently co-occurring word frames.

Mintz (2006) established that English-learning 12-month-old infants use verbal frequent word frames to categorize nonsense words. His work tested the validity of frequent word frames as learning mechanisms by teaching infants nonsense words embedded in the frequent frames (e.g., *gorp* in the frame *you X it*) and testing them on the same words in frames of the same category (e.g., *I gorp you*) or of a different category (e.g. *a gorp of*). Therefore, the most plausible way to answer the question whether Dutch infants use frequent word frames is to replicate Mintz's (2006) experiment with similarly-aged children in Dutch. The results depend on whether using frequently co-occurring words is a general learning mechanism for categorization, irrespective of any smaller co-occurring non-adjacent units available in the language. If infants use frequently co-occurring words as a category-indicative property, it is expected that Dutch 12-month-olds show the same sensitivity to frequent frames as the English 12-month-olds did. However, if the general learning mechanism is not the use of frequently co-occurring words but rather of the smallest frequently co-occurring units in the language, the expectation changes: Dutch children may then not use word frames but rather morpheme frames.

In §5.2, the frequent word frame (FWF) experiment is reported, and in §5.3 the frequent morpheme frame (FMF) experiment. The FWF experiment was carried out

with both 12-month-olds and 16-month-olds in order to track the development of sensitivity towards word frames. The FMF experiment was run only with 16-month-olds, a different group than those used in the FWF experiment.

5.2. Use of frequent word frames by Dutch infants

The FWF experiment reported here²⁰ was designed to test the cross-linguistic viability of using frequent word frames as a general mechanism for categorizing verbs and nouns. If using frequent word frames is a general mechanism for categorizing verbs and nouns, it is expected that Dutch infants exploit this mechanism and show use of frequent word frames for categorization. Despite the lower accuracy of the Dutch frame-based categories (see §4.3.2), the frequency of the word frames in the Dutch input is similar to the frequency of the word frames in the English input. If the frequent co-occurrence of two words with exactly one intervening word is a property used by children to categorize the intervening words, both Dutch 12-month-olds and 16-month-olds will use frequent word frames. However, if the frequent co-occurrence of two elements with the smallest possible position intervening is a property used by children to categorize the intervening forms, neither Dutch age groups will use frequent word frames. A mixed outcome, in the sense that the older Dutch age group uses frequent word frames but the younger age group does not, would point to a later sensitivity to word frames in Dutch relative to English, due to the less consistent cues to be obtained from the word frames.

5.2.1. Stimuli

The stimuli for the perception experiment consisted of short sentences in which nonsense words were embedded in eight different frequent word frames – four verbal and four nominal. The selection of the four nonsense words used in the experiment was based on their phonological make-up and the ease with which adult native speakers of Dutch could perceive the words in the contexts of the stimuli. For example, since the second word of the frame *de X van* ‘the X of’ starts with the voiced fricative [v], which is assimilated to a directly preceding voiceless fricative, a nonsense word ending in the voiceless fricative [f] would be difficult to perceive in this context. Trommelen (1989, and see §4.2) showed that Dutch nouns display more variance in phonological structure than verbs. Since it has been shown that adults are sensitive to these phonological differences indicative of category, the nonsense items

²⁰ This experiment has also been reported in Erkelens (2008)

used here had to be phonologically ambiguous, in the sense that the word could equally well be a noun or a verb. Therefore, only non-words with a segmental make-up similar to those that were classified equally often as nouns and as verbs by Dutch adult speakers were selected. Two nonsense items had a CCVC structure (*plif* [plɪf] and *klot* [klɔt]), whereas two others had CVC structures (*daap* [dap] and *sook* [sok]). Each type of frame contains two nonsense items, one with each segmental make-up. The division of nonsense words over frame types was counterbalanced across two test groups, A and B, such that *sook* and *plif* for example were verbs for the A group but nouns for the B group.

The selection of the frames used in the experiment was based on the input analysis reported in §4.3. The following criteria, formulated originally by Mintz (2006: 52), were used to select frequent word frames for the Dutch experiment: (a) the frames have to be among the frequent word frames in as many different corpora as possible, and (b) there is no overlap between framing words (i.e., if the frame *you X that* is selected, all other frames starting with *you* or ending with *that* are excluded). Like Mintz, I added four training sentences (one for each nonsense word) that did not contain frames, but bigrams (i.e., frequently co-occurring combinations where the first word serves as the context for the second, as in *the X* or *you X*) to make sure that the children would segment the nonsense words. In these four bigram sentences, the bigram was always at the end of the sentence, which increases the chance that the nonsense words will be segmented (see Jusczyk & Aslin, 1995). The final selection contained three verbal and three nominal frames that were frequent in as many different corpora as possible, as well as one verbal and one nominal bigram.

The selection criterion of no overlap between framing words was impossible to implement for Dutch verbal frames: there simply were no three different verbal frames without any overlap in the framing words. This is due to the presence of verbal inflection in Dutch. The children should have access only to the frequent word frame information, so frames with personal pronouns that require an inflected form cannot be used in the FWF experiment. The only Dutch pronouns that do not require an overtly inflected verb form are first person singular (*ik* 'I') and second person singular inverted (*je* 'you'). Some minimal overlap in the framing words must be accepted, in the sense that one of the pronouns *ik* and *je* has to be used twice. A post-hoc test can reveal whether any significant results are due to the test item with only that specific pronoun, which would point to lexical storage of word combinations rather than categorization.

The four verbal frames that were among the frequent in all of the four input corpora are: *wat X je* 'what X you', *dan X je* 'then X you', *ik X het* 'I X it' and *ik X niet* 'I X not'. Of these four frames, three have to be selected as the experimental

frames. Because the pronoun *het* ‘it’ is ambiguous in Dutch, in the sense that it can also be a definite determiner (‘the’), *ik X het* was not selected. Since *ik* is the only pronoun preceding a verb that selects a bare stem as its verb form, the verbal bigram is *ik X ‘I X’*. This resulted in the verbal frames in (1).

- | | | |
|-----|------------------|--------------|
| (1) | <i>wat X je</i> | ‘what X you’ |
| | <i>dan X je</i> | ‘then X you’ |
| | <i>ik X niet</i> | ‘I X not’ |
| | <i>ik X</i> | ‘I X’ |

For the nominal frames the selection criterion of being among the frequent word frames across as many corpora as possible cannot be met. There are not enough nominal frames among the frequent word frames from the corpus analysis, since they occurred in the Dutch input speech much less frequently than the verbal frames. Therefore, frames had to be added that do not occur in the 45 most frequent word frames from the corpora. Since Dutch has gender marking on the determiner it was important to ensure that no gender violations could occur within the nonsense items. The stimuli were selected in such a way that all nonsense items had common gender, which means that they could be combined with the definite determiner *de* ‘the’, the indefinite determiner *een* ‘a’, and the demonstratives *die* ‘that’ and *deze* ‘this’. After the selection of the three most frequent nominal frames in the corpora, the only preceding word with common gender left was *deze*, so the nominal bigram for Dutch is *deze X* ‘this X’. The nominal frames selected for the experiment are in (2).

- | | | |
|-----|------------------|---------------|
| (2) | <i>de X van</i> | ‘the X of’ |
| | <i>een X op</i> | ‘a X on’ |
| | <i>die X die</i> | ‘that X that’ |
| | <i>deze X</i> | ‘this X’ |

In Table 5.1, the resulting set of verbal and nominal frames used in the experiment are presented, along with their accuracy and frequency scores. The overall frequency of the frames used in the stimuli is comparable to the frequency of the English frames used in the experiment by Mintz (2006).²¹ However, as can be observed from Table 5.2, the Dutch verbal frequent word frames seem slightly more frequent than the English ones, whereas the Dutch nominal frequent word frames

²¹ For this comparison I used only the English corpora of Peter, Eve, Nina, and Naomi, since these are comparable in size to the four Dutch corpora. The corpora of Anne and Aran are so-called ‘dense databases’, which are not available for Dutch.

seem slightly less frequent than the English ones (note that the frames used for the experiment overall are less than 1% of the entire input, except for the *wat X je* frame that is almost 2%). These differences were not significant, however ($\chi^2(1) = 2.00$, $p = .16$). The frequency of the frames used in this Dutch experiment can therefore be considered equal to the frequency of the frames used in the English experiment.

Table 5.1. Frequency and accuracy across the four Dutch CHILDES corpora (Matthijs, Sarah, Daan, Laura, see §4.3.2) of frames used in the stimuli for the FWF experiment.

Frame	Mean accuracy (standard, tokens)	Mean frequency (percentage of total number of utterances)
dan X je	0.96	0.51
wat X je	0.99	1.73
ik X niet	0.54	0.34
All verbal frames	0.83	0.86
de X van	0.95	0.15
een X op	0.73	0.23
die X die	0.43	0.15
All nominal frames	0.70	0.18

Table 5.2. Frames used in the stimuli of the FWF experiments in English and Dutch: frequency of occurrence in input corpora as percentage of the total number of utterances in those corpora.

	English	Dutch
Verbal frames	0.75	0.86
Nominal frames	0.32	0.18
All frames	0.54	0.52

Two of the nonsense words were presented in verb frames, and two others in noun frames. In the test phase the children heard the same nonsense words presented

in new frames that were either consistent or inconsistent with the training frame type. So if children heard the nonsense word *plif* presented in a verb frame during the training phase, the test sentence *ik plif niet hoor* ‘I plif not, ok’, in which the word *plif* is in a verb frame again, would be consistent with training. In contrast, the test sentence *er ligt een plif op de kast* ‘there lies a plif on the cupboard’, with a nominal frame, would be inconsistent. The complete set of stimuli, with the Dutch frames and nonsense items applied to the experimental set-up of Mintz (2006) is presented in Table 5.3. The number of sentences is exactly the same as in Mintz’s design and sentence length has been matched as closely as possible. As a consequence of this matching for length, the stimuli with the frame *die X die* ‘that X that’ are not complete sentences in Dutch, but only noun phrases. These noun phrases already consist of five words (*die X die daar staat* ‘that X that stands there’) and at least two other words would have to be added to make full sentences. So only noun phrases were presented and it was checked afterwards whether differences in listening times occurred with these stimuli in comparison to the full sentence stimuli (see §5.2.5).

Table 5.3. Stimuli for the FWF experiment with Dutch infants: training sentences for two counterbalanced groups A and B and test sentences with reversed consistencies for both groups; nonsense words are italicized and frames are in bold and italics.

GROUP A	
VERB FRAME TRAINING SENTENCES	NOUN FRAME TRAINING SENTENCES
<i>Dan plif je</i> de kamer	Ik zie <i>de daap van</i> pappa
<i>Dan sook je</i> de kamer	Ik zie <i>de klot van</i> pappa
Ze zien dat <i>ik plif</i> .	Hij wil <i>deze daap</i> .
Ze zien dat <i>ik sook</i> .	Hij wil <i>deze klot</i> .
<i>Wat plif je</i> daar?	Er ligt <i>een daap op</i> de kast.
<i>Ik sook niet</i> hoor.	<i>Die klot die</i> daar staat.
GROUP B	
VERB FRAME TRAINING SENTENCES	NOUN FRAME TRAINING SENTENCES
<i>Dan klot je</i> de kamer.	Ik zie <i>de sook van</i> pappa.
<i>Dan daap je</i> de kamer.	Ik zie <i>de plif van</i> pappa.
Ze zien dat <i>ik klot</i> .	Hij wil <i>deze sook</i> .
Ze zien dat <i>ik daap</i> .	Hij wil <i>deze plif</i> .
<i>Wat klot je</i> daar?	Er ligt <i>een sook op</i> de kast.
<i>Ik daap niet</i> hoor.	<i>Die plif die</i> daar staat.
TEST ITEMS	
CONSISTENT-A, INCONSISTENT-B	INCONSISTENT-A, CONSISTENT-B
<i>Wat sook je</i> daar?	<i>Wat daap je</i> daar?
<i>Ik plif niet</i> hoor.	<i>Ik klot niet</i> hoor.
Er ligt <i>een klot op</i> de kast.	Er ligt <i>een plif op</i> de kast.
<i>Die daap die</i> daar staat.	<i>Die sook die</i> daar staat.

5.2.2. Exclusion criteria

Since the participants in this kind of perception experiment are young (12 and 16 months), their behavior is extremely variable. This results in a high number of excluded participants. The reported drop-out rate for HPP experiments varies from 15 to 40% (Kemler Nelson et al., 1995). Participants are excluded from analysis for various reasons, mostly due to ‘inattentive behavior’. However, this general criterion is operationalized with diverse measures such as (among many others) ‘failure to look for an average of at least 3 seconds during test’ or ‘crying’ (Gómez & Gerken, 1999), ‘excessive fussiness’ (Gómez, 2002), and ‘unresponsiveness or falling asleep’ (Santelmann & Jusczyk, 1998). Although every study reports exclusion criteria, there is no principled system for excluding participants from the analysis. Such a system was developed for this study (Erkelens & Polišenská, 2007).

Factors other than behavior can obviously lead to exclusion as well, namely experimenter or computer errors. Such exclusion takes place even before a child’s behavior is considered. The system designed for this study excluded participants on the basis of their behavior. Aside from technical problems the only valid reason to exclude children from the analysis of this experiment was serious doubt about whether the child was paying attention to the stimuli. The coding system spelled out in Table 5.4 distinguishes four different groups of behaviors that signal the attentiveness of the infant, starting with the signals that indicate a low grade of attention (code I). The fourth group was added for infants that showed mixed behavior on the second and third codes. All infants were coded for their behavior based on these signals. A selection of the infants was double-checked by a second researcher to make sure that the criteria are objectively interpretable. There was 100% agreement between two researchers on the codes.

Infants assigned code I were automatically excluded from further analysis; all other infants were included. With the coding for behavior as an independent variable it is possible to test for interactions between behavior and listening times. If a certain category of behavior turns out to have a significant effect on listening time, it is possible to exclude cases of that category at a later stage.

Table 5.4. Behavior coding during an HPP experiment on the basis of which infants can be excluded from the analysis (Erkelens & Polišenská, 2007).

	Criteria
Code I Infant excluded	<ul style="list-style-type: none"> • Refusing to sit still and managing to get off the caregiver's lap • Crying; giving the impression that the infant is distressed by the situation (face and body expression) • Not reacting to the lights • Not completing the experiment • Looking at the lights for less than one sentence for one or more trials. • Looking at the lights for more than the stimulus lasts in at least half of the experiment.
Code II Infant included, active and alert	<ul style="list-style-type: none"> • Staying on caregiver's lap (sitting or standing) and reacting to the stimuli • Looking back-and-forth multiple times during trials (re-orientation within 2 seconds). • Being physically active in between the trials (turning the whole body to the parent; moving the whole body from the waist up while looking around; waving arms; shaking head).
Code III Infant included, alert	<ul style="list-style-type: none"> • Sitting still on the caregiver's lap • Reacting spontaneously to the lights • Giving an alert impression • Giving a relaxed impression
Code IV Mix of II and III	<ul style="list-style-type: none"> • Behaving according to encoding 2 for at least half of the experiment. • Behaving according to encoding 3 for the other part of the experiment.

5.2.3. Participants

For the age group of 12 months, 72 infants were tested. Of these 72, six turned out to be either prematurely born (2), bilingual (3), or born to a dyslexic parent. Both the initial intake (before an appointment was made) and the intake before the experiment was run included these questions, but some parents forgot to provide this information at the initial intake. The remaining 66 infants were all healthy, monolingual Dutch infants without a familial risk of dyslexia or developmental

delays as a consequence of prematurity. Three infants were excluded before coding, because of experimenter or technical errors. The other 63 infants were coded based on the coding system described in Table 5.4. Children in this age group were quite attentive: 42 were assigned code III (included, alert), 17 code II (included, active and alert), and only 4 code I (excluded). No child was assigned to the mix category IV. The average age of the 59 infants remaining the infants from category I were excluded was 1:00;07 (range 0:11;22-1:01;00). Group A consisted of 30 subjects and group B of 29 subjects. There were slightly more girls (34) than boys (25) in the sample.

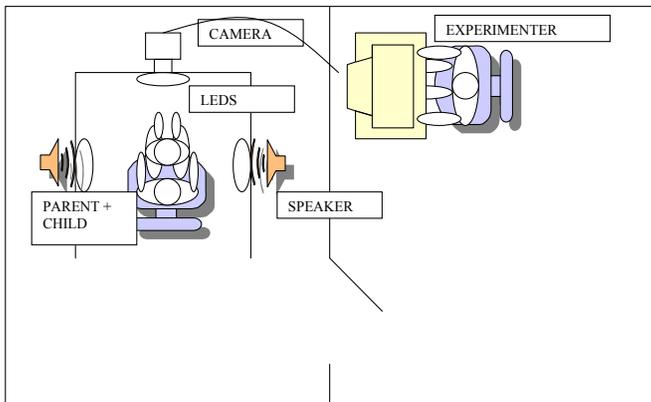
For the age group of 16 months, 65 infants were tested and only one did not meet the inclusion criteria. The remaining 64 infants were all healthy, monolingual, full-term Dutch infants with no familial risk of dyslexia or developmental delays. Four infants were excluded before coding due to experimenter or technical errors. The other 60 infants were again coded based on the coding system in Table 5.4, resulting in 35 ‘included, alert’ (code III), 15 ‘included, active and alert’ (code II), 1 ‘mix of II and III’ (code IV), and 9 ‘excluded’ (code I). After the exclusion of the infants from category I the average age of the remaining 51 infants was 1:04;03 (range 1:03;08-1:04;28). Group A consisted of 25 subjects and group B of 26 subjects. There were slightly more boys (27) than girls (24) in the sample.

5.2.4. Procedure

The experiment conducted by Mintz (2006) was based on the Head-turn Preference Procedure (HPP, see §3.6) with a training phase (Kemler Nelson et al., 1995). The procedure of these experiments is exactly the same. Infants were tested in a three-sided booth made of cloth.²² The top of the booth was also covered with the same kind of cloth, to prevent the child from being distracted by the lamp in the ceiling of the lab. Infants were seated on the parent’s lap, with their heads directed towards the middle wall of the booth. A circle of green LED-lights was mounted at the eye-level. Just above the lights, a camera was installed to record the behavior in the test booth. The experimenter was seated behind a monitor in the adjacent room and observed the child in order to score the head-turns. Circles of red LED-lights were mounted on both sidewalls. The speakers from which the stimuli were played were situated behind the red lights, out of sight for the child. Figure 5.1 shows the experimental set-up used in this experiment.

²² I used the LOT / UiL-OTS facilities at Utrecht University, *Utrechts BabyLab voor Taalontwikkeling* ‘Utrecht BabyLab for Language Development’.

Figure 5.1. Experimental set-up for the HPP experiment with Dutch infants.



The experiment had three phases: a training phase, a contingency training phase, and a test phase. In the training phase, the child heard the training sentences appropriate for the group to which she belonged, as outlined in Table 5.3: group A heard the first set of training sentences and group B the second set, with the two sets differing only in the kind of nonsense words embedded in the frames. The training sentences were played continuously, divided over six randomized blocks each of which contained all training sentences in a random order. In the randomized orders no two sentences with the same frames followed each other, no three sentences with the same nonsense word followed each other, and no block began with *dan X...* ‘then you X...’ as a first sentence. The reason for this last restriction was that the conjunct *dan* ‘then’ in Dutch is always preceded by some content that locates the time or place of the following utterance, so it would have been very unnatural to start a block of sentences with it. During training the lights as described below were initially influenced by the child’s looking, but once the training block started, the sound kept playing and the light stayed on independently of the child’s looking behavior, to make sure every infant heard all the training sentences. Each training trial lasted 19 seconds, adding up to almost two minutes for the entire training phase.

Between the training and test phases, a brief contingency training phase was inserted. The aim was to teach the children that their behavior influenced the lights and the auditory stimulus, i.e., that there was a contingency between their head-turn, the lights, and the sounds. In this phase, the center light was activated until the child turned her head towards the center for at least 2 seconds. The light then went out and a light on one of the sides was activated. As soon as the child looked at the side

light, a tone of 500 Hz was presented from the loudspeaker behind that light. The tone lasted 1 second and was repeated at 100 millisecond intervals as long as the child looked at the light. If the child looked away, or after the 15 repetitions had ended, whichever came first, the center light flashed again and a second, similar trial started. Each contingency trial lasted maximally 16.5 seconds if the child listened to all 15 repetitions. The maximum total duration of the contingency training phase therefore was 33 seconds.

After two contingency training trials, the test phase started. The method was similar to that of the contingency training phase. The tones were replaced by the test sentences in Table 5.3. Each sentence was repeated 15 times in a trial, with pauses between the repetitions of 500 milliseconds. There were 8 test trials, one for each test sentence. These trials were presented in a random order. Both groups heard the same test sentences, because the consistent sentences for group A were the inconsistent ones for group B and vice versa. The mean length of the test sentences was about 2 seconds. This means that one trial lasted around 35 seconds if the child listened to all 15 repetitions. The maximum duration of the test phase therefore was 280 seconds (4 minutes and 40 seconds).

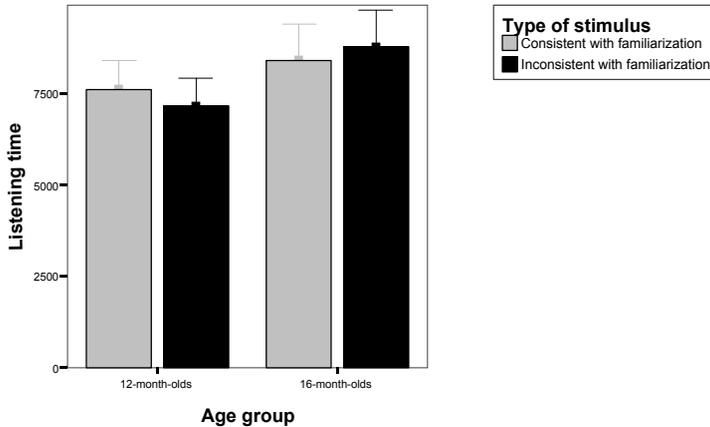
Which side of the child the stimulus was presented was randomized by the computer, but constrained so that no more than 3 consecutive trials came from the same side. The absolute maximum duration of the entire experiment (that is, if the child listened to all trials until they ended, which in practice never happened) was 440 seconds, i.e., 7 minutes and 20 seconds.

5.2.5. Results

The two age groups showed divergent tendencies in their listening times to different types of stimuli. The average listening times of the 12-month-olds are longer for items that were consistent with familiarization; those of the 16-month-olds are longer for items that were inconsistent with familiarization (Figure 5.2 - an overview of all average listening times is provided in Appendix 5.1)

An analysis of variance to investigate the significance of these apparent effects of consistency and age can only be performed if the data are normally distributed. A Kolmogorov-Smirnov test for testing the distribution of the data revealed that this was not the case for the present data set ($Z = 5.00$, $p < .001$). The data therefore had to be normalized by computing the logarithms of the listening times. The distribution of the logarithms did not differ significantly from a normal distribution ($Z = 0.91$, $p = .38$), making an ANOVA possible.

Figure 5.2. Average listening times (in msec) per stimulus type, divided by age group (12 and 16 months) in the FWF experiment.



A mixed ANOVA with four between- and two within-subject factors (between-subjects: age group (2), test group (2), gender (2), behavior (2) x within-subjects: stimulus type (2), frame type (2)) carried out on these log values revealed that none of the factors had a significant main effect on the listening times. Age is the only marginally significant main effect ($F(1,93) = 3.55, p = .06$). This might indicate that the two age groups differ from each other in listening times to the stimuli, but this marginally significant effect does not interact significantly with consistency ($F(1,93) = 0.15, p = .70$), or frames ($F(1,93) = 0.70, p = .40$). Without significant the main effect cannot be meaningfully interpreted.

There was a significant four-way interaction of frame type x age group x gender x test group ($F(1,93) = 6.63, p < .05$), and a significant five-way interaction of frame type x age group x gender x test group x behavior ($F(1,93) = 5.28, p < .05$). None of the other effects and interactions were significant. The two significant interactions indicate that the between-subjects factors age group, test group, gender, and behavior have a combined influence on the average listening times, but this observation does not contribute to a better understanding of the categorization process. The only useful insight from these interactions is that the participants responded differently to different frame types but that this factor had no significant influence on the overall results.

Since some of the stimuli were noun phrases rather than sentences, it had to be established that this factor had no influence on the results. Mean listening times per

stimulus varied from 7.0 seconds (*die sook die daar staat*) to 9.1 seconds (*wat daap je daar?*). An overview of the average listening times to the eight different stimuli is presented in Table 5.5. The difference between the stimuli to which these infants listened for the shortest time (stimulus 8) and longest time (stimulus 3) is significant in a pair-wise comparison using t-tests ($t(109) = 2.75, p < .01$). No other pairs of stimuli differed significantly in listening times. In particular, the two noun phrase stimuli with the frame *die X die* (stimuli 6 and 8) do not differ significantly from any of the other stimuli, indicating that the design using incomplete sentences did not influence the children's reaction times.

Table 5.5. Average listening times per stimulus (in msec) in the FWF experiment.

Nr	Stimulus	Mean listening time (msec)
1	wat sook je daar	8467.12
2	ik plif niet hoor	7729.85
3	wat daap je daar	9141.51
4	ik klot niet hoor	7854.29
5	er ligt een klot op de kast	7853.00
6	die daap die daar staat	7441.47
7	er ligt een plif op de kast	7982.30
8	die sook die daar staat	7044.28

To summarize the results of the FWF experiment, neither age group differentiated between consistent and inconsistent items. Thus there is no evidence that Dutch infants use frequent word frames as defined by Mintz (2003) to categorize nonsense words, at least in the period up to 16 months of age.

5.3. Use of frequent morpheme frames by Dutch infants

Although Dutch infants do not seem to use the frequent word frames as defined by Mintz (2003) for categorization, this does not mean that we must completely reject the proposal that children use frequently co-occurring elements for a first categorization. Even if frequently co-occurring words do not provide reliable cues for an initial categorization, frequently co-occurring morphemes might.

Earlier studies have shown that infants are sensitive to frequently co-occurring non-adjacent elements with variable intervening material (Santelmann & Jusczyk, 1998; Gómez & Gerken, 1999; Poliřenska, in progress). The precise level of

analysis does not need to be the level of words, but could be the level of morphemes. If it is assumed that the level of analysis of frequent frames is language-specific, it is to be expected that Dutch infants will use frequent morpheme frames for categorization whereas English infants use frequent word frames. However, if the Dutch infants in the experiment reported below do not show use of frequent morpheme frames, there is no evidence that Mintz' results with the English infants indicate a general learning mechanism for verb and noun categorization.

The frequent morpheme frame (FMF) experiment reported here²³ was based on the assumption that, if infants search in the input for the smallest, frequently co-occurring non-adjacent units, Dutch infants should find morpheme frames first. The experiment was designed to test whether Dutch infants are able to extract these morpheme frames and use them for early categorization of the intervening words. Polišenská (in progress) has shown that Dutch 18-month-olds are sensitive to verbal inflectional morphemes. It was therefore decided to conduct the FMF experiment with 16-month-olds to provide a point of comparison with the previous study.

5.3.1. Stimuli

The morpheme frames used in this experiment were first selected on their frequency of occurrence in the input corpora of the study reported in §4.3.2. Since morphemes had not been isolated in the transcriptions of these corpora, they had to be identified based on the graphemes with which verbal and nominal morphemes are written in Dutch. Dutch verbal and nominal morphemes are all suffixes, so all trigrams (i.e., sequences of three words) in the input to the four Dutch children were alphabetically ordered according to 'the two final' and 'the final' graphemes of the middle word in the trigram. The result of this ordering thus shows all central words of the trigrams that end with a certain verbal or nominal morpheme in a row. This made it possible to select all central words for which the final graphemes were *-en*, *-t*, *-s*, or *-je*. These are the written forms of the Dutch morphemes for verbal plural (*-en*), nominal plural (*-en* and *-s*), second and third person verbal singular (*-t*), and nominal diminutive (*-je*). This selection resulted in five different lists of trigrams in which the middle word ended in verbal plural *-en*, verbal second/third person singular *-t*, nominal plural *-en*, nominal plural *-s*, and nominal diminutive *-je*.

Of course, not all Dutch words ending in *-en*, *-t*, *-s*, or *-je* contain verbal or nominal morphemes. If children use morpheme frames to categorize the intervening words, they might erroneously segment and then categorize non-existing word parts such as *oran*, *neu*, and *fi**t* (based on the analysis of *oran-je* 'orange', *neu-s* 'nose',

²³ This experiment will also be reported in Erkelens, Kerkhoff & De Bree (in prep).

and *fiet-s* 'bike'). That is, that the use of frequent morpheme frames might lead Dutch children to overestimate the word inventory of Dutch by the child. But the burden of these extra non-words probably does not weigh heavy against the benefits of all the correctly categorized real words, and in the absence of positive evidence in the input for their existence, they probably will not survive for long in the child's lexicon.

From the five lists, those combinations of preceding words and following morphemes were selected that occurred more than 10 times in each corpus. These combinations are called 'frequent morpheme frames', analogous to Mintz's frequent frames of word forms. A morpheme frame is a combination of a preceding morpheme (in Dutch mostly a whole word) and a following morpheme with exactly one stem intervening. The intervening stems can be derived (e.g., Dutch stems like *be-tref* 'concern' or *ver-koop* 'sell'), but not inflected (participle stems like *ge-lop-* 'PART-walk-'). A morpheme frame was taken to be frequent if it occurred more than 10 times in each of the input corpora investigated. For verbal plural *-en* (e.g. *wij lopen*, 'we walk'), 13 different frequent morpheme frames were found, 11 for verbal second/third person singular *-t* (e.g. *hij loopt* 'he walks'), 2 for nominal plural *-en* (e.g. *de bloemen* 'the flowers'), 2 for nominal plural *-s* (*de tafels* 'the tables'), and 2 for nominal diminutive *-je* (*een boekje* 'a book-dim'). This means that both verbal and nominal frequent morpheme frames are available in the Dutch input. However, there are more different verbal frequent morpheme frames, whereas the nominal frequent morpheme frames are more frequent.

Since this experiment was a close replication of the FWF experiment reported in §5.2, the frames and nonsense words for the stimuli were selected in a similar way. The nonsense words *sook* and *plif* were used again, because they are maximally ambiguous between verb and noun in terms of their phonological make-up (§4.2), and they can easily be inflected with all verbal and nominal morphemes. The nonsense word *klot* had to be replaced because it ends in *-t*, making it impossible to distinguish between the stem form and the verbal singular *-t* ending. *Klot* was therefore replaced with another CCVC form, *frep*. The nonsense word *daap* was also changed to *taaf*.²⁴ According to recent insights by Monaghan, Christiansen & Chater (2007), initial voiced consonants are indicative of verbhood in Dutch. Monaghan et al. also found that fricatives are generally more likely to occur in verbs, whereas initial plosives are associated with nouns. To control for this factor,

²⁴ The spelling of the nonsense words presented here uses Dutch spelling conventions. The final consonants of *frep* and *plif* are doubled between two vowels and the vowels of *taaf* and *sook* are written as a single vowel if an *-en* ending is added. There are thus two alternating stems for each nonsense word: *taaf-/taf-*, *sook-/sok-*, *plif-/pliff-*, and *frep-/frep-*. These differences have no effect on the pronunciation.

both types of non-words occurred in both groups: *taaf* and *frep* as verbs for the A-group and nouns for the B-group, and *sook* and *plif* as verbs for the B-group and nouns for the A-group.

Following the selection criteria of Mintz (2006) and the FWF experiment reported in §5.2, the aim was to select morpheme frames that were frequent in all input corpora, and that showed no overlap in framing words. But since there are only two different verbal suffixes (*-en* and *-t*) some overlap in the morphemes had to be allowed. Although Dutch has two different nominal plural morphemes, *-s* and *-en*, the expected plural morpheme for monosyllabic words ending in obstruents is *-en* (Baayen, Schreuder, Jong, & Krott, 2002). Since all the nonsense words were monosyllabic, it would have been unnatural to use the nominal plural *-s* morpheme in the experiment. This meant that the morphemes of the frequent morpheme frames used in the experiment were verbal *-en* and *-t*, and nominal *-je* and *-en*. As in the FWF experiment, two bigram frames were included at the end of two additional sentences to make sure that the participants were able to segment the nonsense words.

The four verbal frequent morpheme frames and the verbal bigram selected for use in the experiment are listed in (3) and the four nominal morpheme frames and the nominal bigram in (4). The accuracy scores of all morpheme frames used for the stimuli are provided in Appendix 5.3.

- | | | |
|-----|------------------|----------------|
| (3) | <i>ze X-en</i> | ‘they X-VPLUR’ |
| | <i>we X-en</i> | ‘we X-VPLUR’ |
| | <i>hij X-t</i> | ‘he X-s’ |
| | <i>wat X-t</i> | ‘what X-s’ |
| | <i>ik X-#</i> | ‘I X’ |
| | | |
| (4) | <i>het X-je</i> | ‘the X-DIM’ |
| | <i>een X-je</i> | ‘a X-DIM’ |
| | <i>de X-en</i> | ‘the X-s’ |
| | <i>twee X-en</i> | ‘two X-s’ |
| | <i>deze X-#</i> | ‘this X’ |

In the FWF experiment only three different frames were used per condition. In this experiment four frames were used, because the verbal and the nominal conditions contain an identical suffix. The morpheme *-en* is the plural morpheme in both the verbal frames *ze X-en* and *we X-en* and the nominal frames *de X-en* and *twee X-en*. It is crucial for the design of the experiment that infants do not hear the same

combination of nonsense word and morpheme in two different conditions. For example, if a participant has heard the nonsense word *frep* as a verb in the frame *ze frepp-en* ‘they frep’, the nonsense word *frep* should never occur with the nominal morpheme *-en* for this participant. Without this restriction, nonsignificant results would be ambiguous: perhaps participants do not use morpheme frames for categorization, or perhaps they do but are misled by an ambiguous morpheme. To avoid such confusion, a slightly different experimental set-up was chosen whereby each nonsense word was trained in two different morpheme frames and tested in the other two, non-trained morpheme frames.

Table 5.6 presents the stimuli used in the experiment. As in the FWF experiment, two of the nonsense words were presented in verb morpheme frames and the other two words in noun morpheme frames. In the test phase the children heard the same nonsense words presented in frames not used in training. These frames were either consistent or inconsistent with the training frame type. So if children heard the nonsense word *plif* presented in a verb frame during the training phase (group B), the test sentence *wat plift er nou* ‘what is pliffing there’, in which the word *plif* is again in a verb frame, was consistent with training. On the other hand, the test sentence *ik zie een plifje* ‘I see a plif-DIM’ with a nominal frame was inconsistent with training. Unlike in the FWF experiment, no two nonsense words were trained in the same frame except for the bigrams. For a participant in the A-group, *taaf* and *frep* are verbs, but based on different evidence: *taaf* was trained in two frames with the morpheme *-t* and *frep* was trained in two frames with the morpheme *-en*. During the test phase, the combinations *taaf-t* and *frepp-en* did not occur, but the combinations *taaf-en* and *frep-t* did. If these participants have different listening times for the verbal test items *wat frept er nou* ‘what is frepping there’ and *we tafen niet hoor* ‘we do not taaf-VPLUR, ok’ on the one hand, and the nominal test items *ik zie een frepje* ‘I see a frep-DIM’ and *de tafen zijn hier* ‘the taaf-NPLUR are here’ on the other hand, this is evidence that they have used the morpheme frames for categorization. If both *taaf* and *frep* had been familiarized with the *-en* morpheme, the test sentences would not have contained any nonsense items on the basis of which categorization can be studied, since the *-en* morpheme occurs in both the verbal test sentence *we tafen niet hoor* ‘we do not taaf-VPLUR, ok’, and the nominal test sentence *de tafen zijn hier* ‘the taaf-NPLUR are here’.

Table 5.6. Stimuli for the FMF experiment with Dutch infants: training sentences for two counterbalanced groups A and B and test sentences with reversed consistencies for both groups; nonsense words are italicized and frames are in bold and italics.

GROUP A	
VERB FRAME TRAINING SENTENCES	NOUN FRAME TRAINING SENTENCES
<i>Hij</i> taaft ook hè	Het <i>sookje</i> is daar
<i>Wat</i> taaft er nou?	Ik zie <i>een sookje</i>
<i>We</i> freppen niet hoor	De <i>pliffen</i> zijn hier
<i>Ze</i> freppen altijd	<i>Dat</i> zijn <i>twee pliffen!</i>
<i>Zie je dat ik</i> taaf ?	<i>Wil je deze</i> sook ?
<i>Zie je dat ik</i> frep ?	<i>Wil je deze</i> plif ?
GROUP B	
VERB FRAME TRAINING SENTENCES	NOUN FRAME TRAINING SENTENCES
<i>Hij</i> sookt ook hè	Het <i>taafje</i> is daar
<i>Wat</i> sookt er nou?	Ik zie <i>een taafje</i>
<i>We</i> pliffen niet hoor	De <i>freppen</i> zijn hier
<i>Ze</i> pliffen altijd	<i>Dat</i> zijn <i>twee freppen!</i>
<i>Zie je dat ik</i> sook ?	<i>Wil je deze</i> taaf ?
<i>Zie je dat ik</i> plif ?	<i>Wil je deze</i> frep ?
TEST ITEMS	
CONSISTENT-A, INCONSISTENT-B	INCONSISTENT-A, CONSISTENT-B
<i>Wat</i> frep t er nou?	<i>Wat</i> plif t er nou?
<i>We</i> tafen niet hoor	<i>We</i> soken niet hoor
Ik zie <i>een pliffe</i>	Ik zie <i>een frepje</i>
<i>De soken</i> zijn hier	<i>De tafen</i> zijn hier

5.3.2. Participants

Twenty-one infants were tested for the FMF experiment. All the infants were healthy, full term, monolingual Dutch infants without a familial risk of dyslexia or developmental delays. Since the behavior of the children in the previously run FWF experiment (as categorized according to the coding system discussed in §5.2.2 and by Erkelens & Polišenská, 2007) did not have an effect on the results, for this experiment only the codes I (excluded), or III (included, alert) were applied. Furthermore, infants who listened for less than 2 seconds to a trial were not excluded as before, but that specific trial was left out of the analysis as long as at least half of the trials for that infant remained analyzable. Data from only one infant was excluded for behavioral reasons (code I). The average age of the 20 remaining infants was 1:04;20 (range 1:04;06-1:04;28). Group A consisted of 9 participants and group B of 11 participants. There were more girls (12) than boys (8) in the sample.

5.3.3. Procedure

The procedure of the FMF experiment was identical to that of the FWF experiment described in §5.2.4.

5.3.4. Results

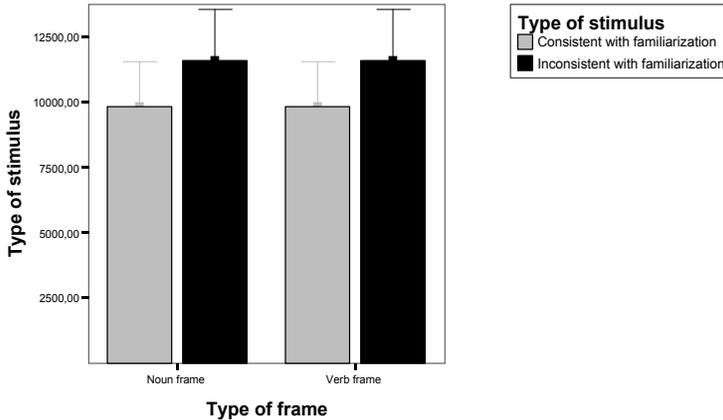
Following the pattern in which the FWF experiment was reported (§5.2.4), the statistical analysis using a mixed ANOVA will be reported in detail; an overview of the average listening times for all the included participants is provided in Appendix 5.2. The average listening times to consistent and inconsistent items (9.8 versus 11.6 seconds) were in general quite different. This difference could in principle result only from one frame type – noun or verb - but Figure 5.3 shows that this is probably not the case, since the listening times for both verb frame and noun frame items differ with respect to consistency.

As for the FWF experiment (§5.4.2), a Kolmogorov-Smirnov test revealed that the distribution of the data differed significantly from a normal distribution ($Z = 2.16$, $p < .001$). So the data were normalized by computing the loglinear values of the listening times. The distribution of the loglinear values did not differ significantly from a normal distribution ($Z = 0.91$, $p = .38$).

A mixed ANOVA (between subjects: test group (2), gender (2) x within subjects: stimulus type (2), frame type (2)) was conducted on the loglinear listening times. There was only one significant main effect of stimulus type ($F(1,15) = 6.56$; $p < .05$). Thus, we can conclude that the differences in listening times to the inconsistent and consistent stimuli are significant. The 16-month-old

Dutch children who had been trained on ‘frequent morpheme frames’ used these frames in the test phase to distinguish between stimuli that were consistent with training and those that were not.

Figure 5.3. Average listening times (in msec) per stimulus type, broken down by frame type in the FMF experiment with infants of 16 months.



To summarize the results of this FMF experiment, the infants distinguished between consistent and inconsistent items. It can be concluded that Dutch infants can use frequent morpheme frames to categorize nonsense words by at least 16 months.

5.4. Conclusion

The experiments reported here addressed the question whether Dutch infants use frequent frames to categorize content words. The experiments showed that, to categorize novel forms, Dutch infants of 12 and 16 months do not use frequent word frames, but by 16 months they do use frequent morpheme frames. Although the frequent frame information as defined by Mintz (2003) is not, then, universally used as an early cue for verbal and nominal categorization, a language-specific version of frequent frames is used in Dutch. The implications of these cross-linguistic differences with respect to the use of frequent frames will be further discussed in the following chapter, which summarizes and discusses the findings of the entire study.

6 Summary and discussion

The studies presented in this thesis investigated when and how Dutch children learn to categorize word forms as verbs and nouns. Taken together, the results of the production, input, and perception studies provide insight into both the development of verbal and nominal representations and the properties of the input that help children in the early stages of this categorization. This final chapter summarizes and discusses the results of the studies, and considers directions for further research. The summary is structured according to the double task children face with respect to verbs and nouns, namely, learning what these categories are and learning how to identify instances of them in the speech stream. Production data were first examined to see how much light they shed on categorization of verbs and nouns. The production studies, to be §6.1, were used to test predictions derived from linguistic theories about verbal and nominal representations in adults. The main objective of these studies was to determine when and how Dutch children learn what verbs and nouns are. A discussion of the input and perception studies follows in §6.2. These studies were designed to investigate when and how Dutch children start to identify verbs and nouns as members of different categories. On the basis of the outcomes of these studies a proposal is made in §6.3 about infants' early categorization strategies. The implications of the findings for ideas about how verbs and nouns are represented in adult grammar are presented in §6.4. Directions for future research are also discussed in these two final sections.

6.1. When and how Dutch children *produce* verbs and nouns

As described in Chapter 2, linguists do not agree on the defining properties of verbs and nouns. From the different ideas discussed it was clear that proposals for the representation of the categories verb and noun in the adult grammar vary substantially. If the end-state categories are not clear, the question when and how children acquire an adult-like representation of verbs and nouns is difficult to investigate. Therefore, the first step taken in this thesis was to translate different ideas about adult verbs and nouns into predictions for the acquisition of these categories by children, and to test these on Dutch children's production data. This procedure was intended to indicate which proposals about the nature of the end-state categories have the most empirical foundation, and to shed light on the developmental steps children take to arrive at these categories.

The theories, which were selected for their focus on the structural properties of verbs and nouns, were examined on the basis of their ideas about how verbs and nouns are represented in the adult grammar. Marantz (1997), Borer (2003), and Baker (2003) propose that the verbs and nouns are represented in adult grammars as discrete categories, characterized by a restricted number of essential syntactic properties (§2.2/§2.3). Hengeveld (1992a, 1992b) defines discrete verbal and nominal representations in terms of the syntactic functions predication and reference. On the basis of his typological work, he claims that grammars of languages differ in their options for verbs and nouns to function as heads and modifiers of predicate and referential phrases, and that these options are structured according to an implicational hierarchy of possible systems (§2.4). Croft (1991, 2000) and Goldberg (1995, 2006) propose that the representations of the categories verb and noun are prototype-like and variable, and differ across languages and even across speakers. The categories are collections of related exemplars in an associative network subject to change with every new language experience (§2.5).

These divergent views on the representation of the categories verb and noun in the adult grammar should ideally lead to different predictions about child language development. Although all proposed grammatical representations of verbs and nouns have to be learnable, it was not straightforward to translate them into predictions for acquisition. In particular, Baker (2003) rejects the use of child language evidence to evaluate a theory since he maintains that language acquisition is not the business of linguists trying to model a grammar (§2.3.1). However, if a grammar explains all adult linguistic data perfectly but is not learnable, it has no connection with the reality of how language works and is therefore of no use to linguistics either. I therefore formulated predictions on the basis of my own interpretation of the theories. The resulting predictions for the course of learning were shown to converge with respect to the early stage of language acquisition. Four of the six theories make similar predictions for early production – that children should show adult-like behavior. Marantz (1997) and Borer (2003) differ from the four other proposals in that they do not predict adult-like production patterns from the start. Hengeveld (1992b) takes a somewhat intermediate position, since, according to his approach the child language production patterns may differ quantitatively from those of adults, but should not differ qualitatively. Two explicitly different predictions were therefore derived from the theories (§2.6): children at an early stage of sentence production either use verbs and nouns in accordance with the adult pattern, or they make a substantial number of categorization errors as a result of mismatches between syntactic structures and lexical items.

These predictions were tested in two production studies (Chapter 3). An analysis of the categorization errors made by Dutch children between 2;6 and 3;6 in their spontaneous speech revealed that such errors are extremely rare (§3.2). This argues against the proposals by Marantz (1997) and Borer (2003) (§2.2) that the syntactic representations of verbs and nouns exist independently of lexical development, although it is still possible, of course that these views hold for an earlier stage of development. The longitudinal analysis of spontaneous production data showed that, as soon as children combine lexical items, they use them in adult-like syntactic structures (§3.3). It should be noted here that it was often difficult to interpret these adult-like production patterns unambiguously due to confounding factors. As shown in §3.2.1 and with the example *dat is trekker* ‘that is tractor’ (example (5) in §3.3.2), the morphological knowledge of children is still developing and it is difficult to distinguish between the omission of grammatical words and errors in category knowledge. Grammatical markers need to be present in children’s speech before the syntactic categories of their words can be determined. In consequence, many utterances, especially from 2-year-olds, are unclear with respect to category. Any steps in development are obscured by these problems of interpretation. It had to be concluded that the question of how children learn verbs and nouns cannot be answered conclusively by analyzing of spontaneous production data. What could be concluded though is that at 2;0 Dutch children already have categories of verbs and nouns that include some syntactic information.

In sum, the picture of verb and noun acquisition that emerges from these production studies is that Dutch children know about verbs and nouns quite early, in the sense that they are able to use them correctly in sentences. But it is unclear whether their representations of verbs and nouns are discrete and defined uniquely, or prototype-like with fuzzy boundaries. Four of the theories from Chapter 2 predict adult-like use for child language production data. Baker (2003) predicts adult-like production patterns because the categories V and N are innately specified. Hengeveld (1992b; Hengeveld & Mackenzie, 2008) predicts adult-like production patterns, at least qualitatively, because children start expressing syntactic functions from the left of the implicational hierarchy and remain within the possibilities of the adult grammar. Croft (1991, 2000) and Goldberg (1995, 2006) predict adult-like production patterns because the categories emerge gradually from the input patterns children perceive. The one general prediction resulting from these four quite divergent theories is borne out. Children at an early stage of sentence production use verbs and nouns in accordance with the adult pattern.

6.2. When and how Dutch children *perceive* verbs and nouns as different categories

The fact that children distinguish verbs and nouns in their production as soon as they start combining words shows that linguistic categorization has already begun at an early stage of development, although it is not clear exactly what this means apart from the ability to use the forms in the correct way. In order to investigate when and how categorization starts, Dutch adults and the input to Dutch children were studied and predictions derived from these studies were tested with perception experiments.

There are at least two potential candidates for input cues that are available early and could lead to categorization: phonological form and co-occurrence patterns (Chapter 4). It was shown that the phonological form of Dutch content words indeed indicates the category, since Dutch adults use phonological form in a consistent way to decide whether a nonsense word is a noun or a verb (§4.2). Four of the five generalizations about the phonological form of Dutch nouns (Trommelen, 1989) led the adult participants to categorize nonsense words as nouns: ‘true’ bi-syllabicity, a final long vowel, a final schwa, and a final schwa followed by [m]. For example, the bi-syllabic nonsense word [melins] was categorized as a noun by almost 90% of the participants. This result makes it likely that children at some point also use phonological form to identify verbs and nouns. The method used with the adults is not suitable for use with children, but an alternative method could be the use of perception experiments. This method has not been used to test for phonological category-indicative properties yet, so it was decided to first replicate for Dutch an earlier experiment on the use of co-occurrence cues as category indicators in English (see §6.3 for a suggestion about such a new experiment to test phonological cues as indicators to categories).

The specific co-occurrence pattern of a ‘frequent frame’ (Mintz, 2003) was the second potential cue to categorization. Dutch input contains frequent word frames that indicate the category of the intervening forms. For example, the category based on the frequent frame *wat X je* ‘what X you’ accurately compares to the category V in Dutch (average standard accuracy score: 0.99). Although word frames are present in the Dutch input, they did not seem to be as reliable as in English (§4.3). But since they are available it was expected that Dutch children would use them to start categorization. However, it was also suggested that Dutch children might use morpheme frames (e.g., *wat X -t* ‘what X -s’) in addition to the word frames, if they pay attention to the local contexts of content word forms frequently occurring in the input.

The role of frequent frames in early categorization was assessed through two perception experiments (Chapter 5). The results of the first experiment showed that

Dutch infants do not use frequent word frames at either 12 months or 16 months of age. Cues for categorization apparently differ across languages, since Mintz (2006) had shown that English infants use frequent word frames for categorization by at least 12 months of age. A second experiment with 16-month-old Dutch infants revealed that these children do, however, use frequent morpheme frames for categorization. The co-occurrence patterns of morphemes in the input play a role in the very early development of verbal and nominal categorization in Dutch children. The fact that co-occurrence patterns of words were used by learners of English but not Dutch indicates that the precise cues used differ across languages.

These results confirm the findings from the production studies discussed above, in that they show that at the very early stages of language acquisition children recognize that verbs and nouns belong to different categories. The categorization mechanism makes use of input properties that are available as soon as children can segment words and morphemes in the speech stream, even before they produce sentences.

6.3. Developmental trajectory of initial categorization

The perception studies have shown that Dutch children learn to distinguish verbs and nouns at an early stage of language development. One of the input properties used as a cue to these categories in Dutch is frequent morpheme frames. An unanswered question is how this categorization process works across input properties and across languages. This section considers the developmental trajectory that may be followed by children in general, taking account of these results from Dutch.

The studies described in Chapters 3, 4, and 5 have shown that learning to categorize verbs and nouns already starts before 16 months. The learning mechanism for categorization therefore has to make use of properties that are available early. Since Dutch adults were shown to use *phonological properties* for categorization these properties may be used in the early categorization process by children. It has also been shown that children use co-occurrence patterns at different levels of granularity. The frequent co-occurrence of *morphemes* (including bound morphemes) is used by Dutch 16-month-olds to categorize verbs and nouns, whereas the frequent co-occurrence of *words* is used by English 12-month-olds to categorize verbs. The correspondence between phonological and co-occurrence properties is that they are both extractable from the speech stream once this speech stream is segmented into phonemes, morphemes and words. Children perceive their native phonemes very early in development (§4.1) and are able to segment morphemes and

words soon after that (§4.3). The proposed trajectory for categorization is that children make use of all the category-indicative properties available in the input speech stream.

Perception studies from earlier research (§4.1 and §4.4) have shown that English-learning infants of 12, 16, and 18 months old are good at extracting sounds, morphemes, and words from the input speech stream. Their phoneme and word segmentation abilities already develop before they are 12 months old. Several studies have shown that learners of English and Dutch are also able to track non-adjacent dependencies between the words and morphemes in a sentence (§4.4.2 - Wilsenach, 2006; Polišenská, in progress). However, as Santelmann & Jusczyk (1998) show, at 18 months this ability is limited to a processing window of five syllables. English 18-month-olds were able to track the dependency between *is* and *-ing* if there were up to three syllables intervening, but not four. This implies that the locality of the dependency plays a role. The limited window for processing non-adjacent dependencies is probably a consequence of a limited short-term memory. Retaining information for a short period is a capacity that develops during childhood (Gathercole, 1999). Infants therefore can keep less information in their memory than adults. The capacity of short-term memory increases with time, so the processing window for frequent frames probably also increases with time.

Children's gradually expanding processing window and the phonological and local co-occurrence properties used in categorization probably interact. At around 9 months, infants can recognize most native phonemes and they start to segment words from the speech stream. From this age on, they have access to phonology as a cue for categorization and could start to make the link between phonology and categories to start categorizing verbs and nouns. When infants have achieved the ability to segment words from the speech stream and their processing window is at least three syllables long, they could also start to use morpheme frames and word frames for categorization. Since the processing window is restricted at a young age, it is plausible that they start out by paying attention to the local dependencies that occur the most frequently in their input, and only gradually extend their attention to more distant dependencies.

This proposed developmental trajectory is expected to hold for all language-learning children, but the differences between English and Dutch have to be explained. English does not have much inflectional morphology. Whether there are reliable morpheme frames and whether these are used by very young English children still needs to be investigated. Mintz (2006) showed that 12-month-old English learners with a three-syllable processing window are able to trace the dependencies between the words in frequent word frames such as *to X it*, and use

them to categorize verbs (§4.4.3). The fact that Dutch 12-month-old infants did not use similar frequent word frames, such as *ik X niet* ‘I X not’ (§5.2), can be seen as a logical consequence of the fact that in Dutch, more often than in English, there is more than one intervening syllable, including especially adverbial particles like *dan* ‘then’, *ook* ‘also’, or *even* ‘just’ (e.g., *ik loop dan niet* ‘then I don’t walk’, *ik ga even niet* ‘I just don’t go’). For an infant to trace the dependency between *ik* and *niet* in these sentences, a processing window of four or five syllables is needed. In retrospect, the negative results of the frequent word frame experiment with Dutch 12- and 16-month-olds can be interpreted as due to a limitation of their processing window. Since English 18-month-olds have a processing window of only five syllables (Santelmann & Jusczyk, 1998), it is likely that these Dutch infants had a more limited processing window. A characteristic property of Dutch –that adverbial particles can occur in various places in a sentence— is then an important obstacle to tracing frequent dependencies between words, because more than five syllables often intervene. Frequent morpheme frames are more local than word frames and do not as easily allow forms other than verbs and nouns to intervene. For example, the Dutch frequent morpheme frame *hij X -t* ‘he X -s’ cannot contain an adverbial particle, since in a sentence like *hij loopt dan niet* ‘then he doesn’t walk’, the adverb falls outside of the frequent morpheme frame dependency. Infants with small processing windows are expected to trace these frequent morpheme frames better than frequent word frames. English infants may also use morpheme frames if these are available in their input.

If the developmental trajectory proposed here works in the same fashion in all language-learning children, a number of predictions follow. First, we can predict that if English 12-month-olds pay attention to the most frequently co-occurring local dependencies in their first language (which happen to be words) and use them to categorize, then so can Dutch 12-month-olds –for morphemes. This expectation can easily be tested by replicating the FMF experiment reported in §5.3 for 16-month-old Dutch infants with 12-month-olds; this work is in progress. Secondly, we can predict that there are links between phonology and categories in all languages. This prediction has been confirmed to some extent by computational linguists (§4.2), but more languages need to be studied to provide a reliable typological sample. Thirdly, we can predict that infants will use any available links between phonology and category in their first language. As explained in §4.5, the experimental design used to test Dutch adults’ sensitivity to these links is not suitable for use with children, but perception experiments may be used. The specific details of such an experiment are complex, because infants need some kind of context to show use of phonological cues, but any context is in itself also a potential

cue to category. The null results of the frequent word frame experiment from Chapter 5 provide new opportunities to test the use of phonological properties by Dutch infants. If the distributional environment of stimuli is held constant, their phonological form can serve as the only difference between them, allowing us to compare children's reactions to two kinds of stimuli. And since the distributional environments in terms of frequent word frames were shown not to be used as cues to category by Dutch infants, we can use these contexts. For example, if a phonological noun (e.g., *giveno*) is presented in the training phase of an experiment and tested in both a noun frame (e.g., *er ligt een giveno op de kast* 'there lies a giveno on the cupboard') and a verb frame (e.g., *ik giveno niet hoor* 'I giveno not, ok'), we can investigate whether infants' listening time differs structurally between phonological nouns in a noun context and phonological nouns in a verb context. If the contexts themselves already trigger categorization, there are no conditions left to use in testing sensitivity to the phonological form. But since Dutch infants did not use the distributional information for categorization in the frequent word frames experiment described in §5.2, it can be assumed that this level of cue will not play a part. Although the design will be complex, then, it should be possible to design a perception experiment that tests for the use of phonological properties by Dutch infants.

Beyond English and Dutch, it is predicted that children learning any first language follow the proposed developmental trajectory. However, the exact predictions for other languages are still difficult to formulate. Languages like Mandarin Chinese are characterized as having hardly any function words or affixes (Li & Thompson, 1981; Tai, 1982; Xu, 1997). For such languages it is harder to decide on the most local dependency that could work as a categorizing frame at the word or morpheme level. The frequent frames discussed so far all consist of function words or affixes, since these in general occur more frequently than content words. Input studies of languages like Mandarin need to be conducted to investigate whether there are any frequently co-occurring non-adjacent elements that may be used for categorization. Only then could they be tested in children. So, although the proposed learning mechanism receives support from the outcomes of the present study on Dutch and on English (Mintz 2003), its cross-linguistic applicability has to be proven based on typologically very different languages.

According to the developmental trajectory proposed here, infants start categorization of verbs and nouns at around 9 months, using phonological properties and maximally local frequent frames as indicators. To test the validity of this mechanism, a number of experiments have been proposed here that would lead to a more complete picture of initial categorization in Dutch. Once this picture is

established, the challenge is to compare languages with different input characteristics to find out what parts of the trajectory are generally applicable. Investigating how children learn to categorize verbs and nouns then becomes a window to the general and the language-specific parts of acquisition.

6.4. Representation of verbs and nouns in adult grammar

In this thesis the question of what verbs and nouns are was approached from the viewpoint of how children acquire an adult mental representation of verbs and nouns. As shown in Chapter 2, linguists have quite different ideas about these representations in the grammar. Generally speaking, there are two main hypotheses: representations are discrete and universal, or they are prototype-like and variable across languages and speakers. My attempt to test these two hypotheses against children's spontaneous production data proved unsuccessful because it could not discriminate between these two main hypotheses with respect to the nature of verbal and nominal representations. So the question of how verbs and nouns are represented in adult grammar remains.

The results of the perception studies show that language-specific input properties are an important factor in the early categorization process. Even between closely related languages such as English and Dutch (both Indo-European), there were differences in the categorization process that could be traced back to language-specific properties of the input. The first categories in the child's grammar are therefore quite context-specific, and differ across languages and probably even across children. Those early categories are shaped by the frequency of local non-adjacent dependencies in the input addressed to the child, and possibly by phonological properties as well.

An important question raised by these results is whether the categories in adult grammar are qualitatively different from these early categories in child grammar. The basic idea of Construction Grammar (Goldberg, 1995), as discussed in §2.5, is that the adult grammar is a more mature version of the child grammar, in which the categories have become more abstract, but not necessarily less prototype-like and variable. The results of the perception studies are compatible with the hypothesis that verbs and nouns are prototype-like categories that vary across languages and across speakers, but this is not the only possible interpretation. There are two conceivable ways in which the acquisition process proposed in §6.3 could lead to verbs and nouns in the adult grammar: the context-specific categories resulting from this acquisition process could either be the precursors of adult prototype-like and variable categories, or they could function as bootstraps to innate discrete categories.

According to the first scenario, the very context-specific categories resulting from children's sensitivity to category-indicative phonological properties and frequent frames in the input gradually become more abstract. As proposed by Goldberg (1995: §2.5), the different categories are part of a larger associative network in which categories overlap. The frame-based categories resulting from the learning mechanism proposed in §6.3 may also overlap in the child grammar. Such overlap between frame-based categories results from shared intervening word forms (see the discussion in Mintz, 2003), or shared framing elements. The Dutch diminutive frames in (1) can be taken as an example of how two very specific frame-based categories may collapse into a single slightly more abstract category.

- (1) a. *het X-je* 'the X -DIM'
 b. *een X-je* 'an X -DIM'

The morpheme frames in (1) show overlap in the framing element *-je*. This kind of overlap may prompt the child to collapse the contents of the two categories resulting from the frames into one larger category. Furthermore, since the 'an X -DIM' frame in (1b) is the indefinite variant of the 'the X -DIM' frame in (1a), the same nouns are likely to occur in both frames; i.e., there will also be overlap between the words occurring in the slots of these two frames. Imagine that the frame-based category arising from the (1a) frame consists of the forms in (2a), and the category arising from the (1b) frame consists of the forms in (2b).

- (2) a. *kop* 'cup' *straat* 'street' *feest* 'party'
 b. *bord* 'plate' *paard* 'horse' *feest* 'party'

The form *feest* occurs in both frame-based categories. Children may use the overlap of *feest* to categorize all forms in (2) together. On the basis of overlap between both shared framing elements and shared intervening word forms, the child grammar will gradually show larger and less context-specific categories of verbs and nouns. Thus, the overlap between the categories of both the framing element *-je* and the intervening word form *feest*, leads to emergence of a larger category of words preceding *-je* containing all forms in (2). This new category of 'forms preceding *-je*' is less context-specific than the former frame-based categories based on the frames in (1). This gradual emergence of larger and less context-specific categories may eventually lead to verbal and nominal representations that are abstract enough to allow speakers to understand and produce completely new sentences.

If verbs and nouns in adult grammar indeed result from the gradual emergence of less context-specific categories, this abstraction process needs to be studied. Adults use their knowledge of verbs and nouns in order to understand and produce grammatical sentences. For example, the unique property of verbs analyzed by Baker (2003) is that they entail a subject position. To judge from the data presented in his and other typological work, this property of 'direct predication' indeed seems to hold for verbs across languages. Since all verbs have this property, the adult grammar should contain a representation that generalizes over all verbs. Irrespective of whether they can ever occur in the same frame-based category, they must eventually end up in the category of word forms that get a subject. Future research must spell out precisely how verbs and nouns gradually emerge in child and adult grammar if we are to explain such linguistic facts about adult category knowledge.

The second hypothetical way in which context-specific child categories can be related to adult categories is not by gradual abstraction but via innate linking rules. Let us assume that adult representations of verbs and nouns are discrete and universal syntactic categories such as those proposed by Marantz, (1997), Borer (2003), Baker (2003), and Hengeveld (1992b - if only the syntactic functions HP, HR, MR, and MP, and not the word classes expressing them, are taken into account). The child categories then are not a direct precursor of the adult categories, as in the "gradual emergence" account, but rather serve as a kind of 'bootstrap' to the adult categories. The idea that input-based categories can serve as a bootstrap to innate syntactic categories was first developed for semantic categories (Grimshaw, 1981; Pinker, 1984). This 'semantic bootstrapping' entails that the child forms her first categories based on shared concepts such as 'action' or 'event'. By means of innate Canonical Structural Realizations of the type 'action meanings are realized by Vs', she bootstraps from the semantic category 'action' to the innate syntactic category 'V'. Not all words with an action meaning are verbs (see also §1.2), so the semantic category 'action' is not a direct precursor of the category 'V'. However, this child category of action words can still help the child to arrive at the syntactic category of V, according to Grimshaw and Pinker.

It is certainly conceivable that the frame-based verbal and nominal categories in child grammar work in a similar way to bootstrap the innate syntactic categories V and N that have been proposed by Marantz (1997), Borer (2003), and Baker (2003), or to the innate syntactic functions HP and HR proposed by Hengeveld (1992b). There is, however, one important difference between semantic properties on the one hand and the phonological and co-occurrence properties discussed in this study on the other hand. The links between semantics and syntactic categories are, by hypothesis, more or less valid across languages, so innate linking rules can be

specified that work for most languages in the world. Since information about phonological properties or frames is completely language-specific, it is more difficult to formulate linking rules that can be part of a universal grammar. A linking rule such as ‘categories based on frames with “you” are realized by Vs’ only works for English, since other languages do not have the word form ‘you’.

A slightly different kind of linking rule is proposed by Mintz (2003). Both in his input study and in the Dutch input study reported in §4.3 there were more frame-based categories containing verbs than nouns. If children collapse frame-based categories on the basis of the overlap between intervening words, they will end up with a large frame-based category of verbs and a smaller frame-based category of nouns. Their grammar in this case can contain a linking rule that says ‘the larger category is realized as V’. In other words, a general property of the frame-based category, such as its size, can serve as a bootstrap to an innate, discrete category.

The results of the studies reported in this thesis cannot give conclusive evidence supporting either discrete or prototype-like representations of verbs and nouns in adult grammar. The two possible ways in which the early context-specific child categories could lead to adult representations both need further research.

This study tried to translate different theories about the grammatical representation of verbs and nouns into predictions for spontaneous production data. As was shown in Chapter 3, spontaneous production data can only be analyzed reliably for verbs and nouns when children produce multi-word utterances. For this stage of development, almost all the theories made the same prediction, that children’s use of words as verbs or nouns would be adult-like from the beginning. This prediction was indeed borne out. But even theories that predicted errors cannot be ruled out on the basis of these data, since errors might have occurred at a still earlier stage. For future research, then, it may be worthwhile to compare the theories discussed in Chapter 2 in more detail with respect to their predictions for earlier stages of development. Borer (2004) showed that the categorization errors predicted by her theory show up at a very early stage in Hebrew, since children already have the adult syntactic representations of verbs and nouns, but do not yet know which words belong to which categories. The predictions for the earliest stages based on the constructionist theories discussed in §2.5 are diametrically opposite; they predict literal imitations of the input language, i.e., no errors at all.

The future challenge is to translate opposing ideas about the representation of verbs and nouns in the adult grammar into testable predictions for early child language. As becomes clear from this study, this is a difficult task, and this is not only because it is hard to derive distinguishing predictions for child language from

the theories, but also because most methods suitable for testing younger children do not lead to an unambiguous interpretation of the underlying representations.

Appendices

Appendix 3.1 – Raw numbers of content words per word class in the longitudinal production study.

Appendix Table 3.1.1. Raw numbers of content words per word class used by children at different MLU points and a control group of adults to express the syntactic function HP.

MLU	V	N	A	Other	Total
< 2,0	394	101	34	191	720
2,0 - 2,5	1364	290	163	420	2237
2,5 - 3,0	3225	374	448	758	4805
3,0 - 3,6	2731	54	264	709	3758
Adults	255	2	54	11	322

Appendix Table 3.1.2. Raw numbers of content words per word class used by children at different MLU points and a control group of adults to express the syntactic function HR.

MLU	V	N	PrN	Other	Total
< 2,0	0	634	207	8	849
2,0 - 2,5	6	2002	471	14	2493
2,5 - 3,0	21	3935	756	46	4758
3,0 - 3,6	11	2451	380	48	2890
Adults	0	243	29	7	279

Appendix Table 3.1.3. Raw numbers of content words per word class used by children at different MLU points and a control group of adults to express the syntactic function MR.

MLU	V	N	PrN	Other	Total
< 2,0	3	51	13	1	68
2,0 - 2,5	12	171	12	4	199
2,5 - 3,0	5	319	28	2	354
3,0 - 3,6	9	247	4	6	266
Adults	2	44	0	0	46

Appendix Table 3.1.4. Raw numbers of content words per word class used by children at different MLU points and a control group of adults to express the syntactic function MP.

MLU	V	N	PrN	Other	Total
< 2,0	1	1	0	0	0
2,0 - 2,5	11	3	8	0	0
2,5 - 3,0	50	42	8	2	2
3,0 - 3,6	90	70	20	0	1
Adults	15	15	0	0	0

Appendix 4.1 - Instructions provided to participants in the phonology study

*Hartelijk dank dat je even de tijd wilt nemen om de volgende taak uit te voeren. Je ziet hieronder een lijst van woorden. De eerste paar zullen je bekend voorkomen, de overige niet. De bedoeling is dat je van elk van deze woorden zegt of het de stam van een **werkwoord** is, of dat het de stam van een **zelfstandig naamwoord** is.*

De stam van een werkwoord is de vorm die je aantreft in onderstaande context:

(i) ik (bijv. ik zie; ik loop; ik ruik)
zie, loop en ruik zijn de stammen

De stam van een zelfstandig naamwoord is de vorm die je aantreft in de context:

(ii) een (bijv. een boek; een huis; een lamp)
boek, huis en lamp zijn de stammen

Je kunt je keuze voor werkwoord of zelfstandig naamwoord aangeven door een kruisje in de betreffende kolom te plaatsen. Let op, je móet een besluit nemen.

(English translation - not in original)

‘Thank you for taking the time to perform the following task. You will see a list of words below. The first few words will be familiar to you, the others will not. The intention is that you indicate for each of these words whether it is the stem of a **verb**, or the stem of a **noun**’

The stem of a verb is the form you see in the context below:

(i) I ... (e.g., I see; I walk; I smell)
see, walk, and smell are stems

The stem of a noun is the form you see in the context below:

(ii) a ... (e.g., a book; a house; a lamp)
book, house, and lamp are stems

You can indicate your choice of verb or noun by putting a check in the relevant column. Take note: you must make a decision.’

Appendix 5.1 – Average listening times in the FWF experiment

Appendix Table 5.1.1. Average listening times broken down by between-subjects factors (in msec).

	Mean listening time (msec)	N
All children	7939.23	110
Age group = 12 months	7383.61	59
Age group = 16 months	8582.01	51
Gender = Male	7865.02	52
Gender = Female	8005.76	58
Test group = A	8024.10	55
Test group = B	7854.36	55
Behavior = included, alert	7941.90	76
Behavior = included, active and alert	7842.14	33
Behavior = mixed	10939.75	1

Appendix Table 5.1.2. Average listening times broken down by stimulus order (in msec).

	Mean listening time (msec)
First	10365.02
Second	7880.75
Third	8035.05
Fourth	8215.46
Fifth	7748.33
Sixth	7626.69
Seventh	7278.87
Eighth	6363.65

Appendix Table 5.1.3. Average listening times broken down by stimulus and frame type (in msec).

	Mean listening time (msec)
Stimulus type = consistent	7976.42
Stimulus type = inconsistent	7902.04
Frame type = verb	8298.19
Frame type = noun	7580.26

Appendix 5.2 – Average listening times in the FMF experiment

Appendix Table 5.2.1. Average listening times broken down by between-subjects factors (in msec).

	Mean listening time (msec)	N
All children	10670.09	20
Gender = Male	10510.62	8
Gender = Female	10703.64	12
Test group = A	11482.38	9
Test group = B	9926.12	11

Appendix Table 5.2.2. Average listening times for each stimulus (in msec).

Nr.	Stimulus	Mean listening time (msec)	N
1	wat frept er nou	9315.71	14
2	we tafan niet hoor	10711.32	19
3	wat plift er nou	8586.74	19
4	we soken niet hoor	11585.11	18
5	ik zie een plifje	10088.81	16
6	de soken zijn hier	11887.29	17
7	ik zie een frepje	13671.22	18
8	de tafan zijn hier	9251.18	17

Appendix Table 5.2.3. Average listening times broken down by stimulus orders (in msec).

	Mean listening time (msec)
First	10012.74
Second	12776.40
Third	10897.76
Fourth	10268.24
Fifth	11521.58
Sixth	9546.38
Seventh	9752.88
Eighth	10739.50

Appendix Table 5.2.4. Average listening times broken down by stimulus and frame type (in msec).

	Mean listening time (msec)
Stimulus type = consistent	9810.75
Stimulus type = inconsistent	11607.55
Frame type = verb	10080.21
Frame type = noun	11277.31

Appendix 5.3 – Accuracy scores of frames used for the stimuli of the FMF experiment

Frame	Standard Analysis		Expanded Analysis	
	Tokens	Types	Tokens	Types
<i>ze X-en</i>	0.72	0.72	0.40	0.43
<i>we X-en</i>	0.59	0.70	0.32	0.38
<i>hij X-t</i>	0.81	0.82	0.41	0.59
<i>wat X-t</i>	0.83	0.57	0.42	0.31
<i>het X-je</i>	1.00	1.00	1.00	1.00
<i>een X-je</i>	1.00	1.00	1.00	1.00
<i>de X-en</i>	0.97	0.96	0.97	0.96
<i>twee X-en</i>	0.96	0.95	0.96	0.95

Abbreviations

Syntactic analyses

HP	Head of a Predicate phrase
HR	Head of a Referential phrase
MR	Modifier in a Referential phrase
MP	Modifier in a Predicate phrase
V	Verb
N	Noun
A	Adjective
Adv	Adverb
PrN	Proper Name
D	Determiner
T	Tense
Spec	Specifier
Pred	Predicating head
v	'little v': functional head that projects the external verbal argument
√	root
VP	Verb Phrase
NP	Noun Phrase
AP	Adjectival Phrase
AdvP	Adverbial Phrase
DP	Determiner Phrase
TP	Tense Phrase
PredP	Predicate Phrase
rootP	root Phrase

Morpho-syntactic glosses

DIM	diminutive marker
3-SG	third person singular marker
PERF	perfective aspect marker
DET	determiner
ART	article

FUT	future tense marker
INF	infinitive marker

Phonological structures

C	consonant
V	vowel

Terminology

MLU	Mean Length of Utterances (in morphemes)
HPP	Head turn Preference Procedure
HAS	High Amplitude Sucking
DM	Distributed Morphology
CHILDES	Child Language Data Exchange System
FWF	Frequent Word Frame
FMF	Frequent Morpheme Frame

Statistical analyses

ANOVA	Analysis of Variance
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Tables

Table 2.1. (page 47)

Summary of the six syntactic theories of verbs and nouns and their predictions for child production data (ordered according to the presentation in this chapter).

Table 3.1. (page 55)

Overview of all candidates for categorization errors from a corpus study of four Dutch children between 2;6 and 3;6, structured according to the category of the adult word form from which the error is derived: nouns, verbs, and adjectives.

Table 3.2. (page 56)

Analysis of all candidates for categorization errors according to the possibility that they represent innovations (filling lexical gaps) or word forms that can occur in multiple categories in adult speech (see Table 3.1 for English translation). + stands for a positive answer to the statement at the top of the column, - stands for a negative answer.

Table 4.1. (page 77)

Overview of the stimuli used in the classification experiment with their Dutch orthography, phonetics, condition and design principle.

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Division of responses over stimulus designs in raw numbers (and percentages) in the phonology experiment with Dutch adults.

Table 4.3. (page 80)

Division of responses over design principles in raw numbers (and percentages) in the phonology experiment with Dutch adults.

Table 4.4. (page 83)

Session ranges for analyzed English input corpora (alphabetically); number of utterances, number of tokens and types categorized by 45 most frequent frames (Mintz, 2003: 96).

Table 4.5. (page 86)

Token and type accuracy for standard and expanded analysis (A), including baseline accuracy of random categories (R) for all English corpora (Mintz, 2003: 100).

Table 4.6. (page 87)

Session ranges for analyzed Dutch input corpora (alphabetically); number of utterances, number of tokens and types categorized by 45 most frequent frames.

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Token and type accuracy for standard and expanded analysis (A), including baseline accuracy of random categories (R) for analyzed Dutch corpora.

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Stimuli for the FWF experiment with Dutch infants: training sentences for two counterbalanced groups A and B and test sentences with reversed consistencies for both groups; nonsense words are italicized and frames are in bold and italics.

Table 5.4. (page 108)

Behavior coding during an HPP experiment on the basis of which infants can be excluded from the analysis (Erkelens & Polišenská, 2007).

Table 5.5. (page 113)

Average listening times per stimulus (in msec) in the FWF experiment.

Table 5.6. (page 118)

Stimuli for the FMF experiment with Dutch infants: training sentences for two counterbalanced groups A and B and test sentences with reversed consistencies for both groups; nonsense words are italicized and frames are in bold and italics.

Figures

Figure 3.1. (page 61)

Percentages of the syntactic functions HP, HR, MR, and MP expressed with a content word by Dutch children at different MLU points and by a control group of Dutch adults.

Figure 3.2. (page 63)

Percentages of content words per word class used by children at different MLU points and a control group of adults to express the syntactic function HP (A = adjective, N = noun, V = verb).

Figure 3.3. (page 65)

Percentages of content words per word class used by children at different MLU points and a control group of adults to express the syntactic function HR (PrN = proper name, N = noun, V = verb).

Figure 3.4. (page 67)

Percentages of content words per word class used by children at different MLU points and a control group of adults to express the syntactic function MR (PrN = proper name, A = adjective, N = noun).

Figure 3.5. (page 68)

Percentages of content words per word class used by children at different MLU points and a control group of adults to express the syntactic function MP (A = adjective).

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Percentages of noun and verb responses per stimulus designed either as a noun (in CAPITALS) or as ambiguous in the phonology experiment with Dutch adults.

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Experimental set-up for the HPP experiment with Dutch infants.

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Average listening times (in msec) per stimulus type, divided by age group (12 and 16 months) in the FWF experiment.

Figure 5.3. (page 120)

Average listening times (in msec) per stimulus type, broken down by frame type in the FMF experiment.

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Samenvatting in het Nederlands

Het doel van dit proefschrift was te onderzoeken hoe Nederlandse kinderen werkwoorden (verba) en zelfstandig naamwoorden (nomina) leren categoriseren. Om dit doel te bereiken zijn er studies uitgevoerd naar de taalproductie van Nederlandse kinderen, naar de eigenschappen van het volwassen Nederlandse taalaanbod en naar de taalperceptie van Nederlandse dreumesen. In deze samenvatting worden de resultaten van deze studies besproken. De samenvatting is gestructureerd aan de hand van de dubbele taak die kinderen moeten vervullen in het leren categoriseren. Ze moeten leren wat de categorieën verbum en nomen inhouden, maar ze moeten ook leren woorden uit spraak te herkennen als verbum of nomen. De studies naar taalproductie hadden vooral tot doel om erachter te komen hoe kinderen leren wat de categorieën inhouden, dus daarom worden die eerst besproken. Daarna zullen de studies naar het taalaanbod en de taalperceptie worden besproken, waarin de vraag centraal staat hoe kinderen woorden uit spraak kunnen herkennen als verbum of nomen.

Wanneer en hoe Nederlandse kinderen verba en nomina produceren

In hoofdstuk 2 van dit proefschrift wordt beschreven dat taalkundigen het niet bepaald eens zijn over wat de definiërende eigenschappen van verba en nomina zijn. Vanuit de verschillende besproken theorieën werd duidelijk dat de voorstellen over hoe verba en nomina zijn gerepresenteerd in de ‘grammatica in je hoofd’ (mentale grammatica) aanzienlijk verschillen. Dit is problematisch voor het onderzoeken van hoe kinderen deze categorieën dan leren, want als het niet duidelijk is wat het einddoel is, is het ook moeilijk om te onderzoeken hoe dat einddoel wordt bereikt. Daarom is de eerste stap die in dit proefschrift wordt genomen het testen van de verschillende theorieën aan de hand van productiedata van Nederlandse kinderen. Om dit te kunnen doen zijn de besproken theorieën over verba en nomina vertaald naar voorspellingen voor de verwerving van deze categorieën. Hierdoor moet het duidelijk worden welke voorstellen over hoe categorieën in de hoofden van volwassenen zitten het meest gesteund worden door empirische gegevens. Bovendien worden op deze manier de ontwikkelingsstappen zichtbaar die kinderen nemen om bij deze categorieën te komen.

Voor elke theorie, geselecteerd om de focus op structurele eigenschappen van verba en nomina, is onderzocht wat het idee is over hoe deze categorieën gerepresenteerd zijn in de volwassen grammatica. Marantz (1997), Borer (2003) en Baker (2003) nemen aan dat de grammaticale representaties van verba en nomina

discrete categorieën zijn, die gevormd worden door een beperkt aantal essentiële syntactische eigenschappen (§2.2 / §2.3). Hengeveld (1992a, 1992b) definieert discrete verbale en nominale representaties in termen van de syntactische functies predikatie en referentie. Zijn typologische werk stelt dat grammatica's van talen verschillen in de mogelijkheden die ze toestaan aan verba en nomina om te functioneren als het hoofd of de modificeerder van predicatieve en referentiële frases. De mogelijkheden worden beperkt door een implicatieve hiërarchie van mogelijke systemen (§2.4). Croft (1991, 2000) en Goldberg (1995, 2006) benadrukken dat de representaties van de categorieën verbum en nomen prototypechtig en variabel zijn. Ze verschillen per taal en zelfs per spreker. De resulterende categorieën zijn verzamelingen van gerelateerde voorkomens in een associatief netwerk dat verandert bij iedere nieuwe taalervaring.

Deze aanzienlijk verschillende ideeën over de representatie van de categorieën verbum en nomen in de volwassen grammatica zouden idealiter uitmonden in per theorie verschillende voorspellingen voor kindertaalproductie. Ook al moeten alle voorgestelde grammaticale representaties leerbaar zijn, toch was de vertaling van de theorieën naar voorspellingen voor taalverwerving niet altijd vanzelfsprekend. Met name Baker (2003) schermt zijn theorie af voor evaluatie door middel van kindertaaldata door te zeggen dat taalverwerving niet de zaak is van taalkundigen die proberen een grammaticaal model te maken (§2.3.1). Maar ook al verklaart een grammatica op een perfecte manier alle volwassen taalkundige data, als hij niet geleerd kan worden heeft hij geen verbinding met de realiteit van hoe taal werkt en daarom is een dergelijke grammatica ook niet bruikbaar voor de taalkunde. Daarom heb ik voorspellingen geformuleerd op basis van mijn eigen interpretatie van iedere theorie. Die uiteindelijke voorspellingen over hoe leren verloopt volgens deze theorieën bleken erg op elkaar te lijken wat betreft vroege productiestadia. Vier van de zes theorieën maakten eenzelfde voorspelling voor vroege productie, namelijk dat kinderen een volwassen gedrag vertonen. Marantz (1997) en Borer (2003) verschillen van de andere vier voorstellen omdat zij geen volwassen gedrag voorspellen vanaf het begin. Hengeveld (1992b) neemt een soort tussenpositie in, want hij voorspelt dat de productiepatronen van kinderen wel kwantitatief kunnen verschillen van die van volwassenen, maar niet kwalitatief. Er bleven daarom twee expliciet verschillende voorspellingen over (§2.6): of kinderen produceren verba en nomina in hun eerste zinnen zoals volwassenen ze gebruiken, of ze maken een aanzienlijk aantal categorisatiefouten doordat ze syntactische structuur en lexicale items verkeerd koppelen.

Deze voorspellingen zijn getest door middel van twee productiestudies (hoofdstuk 3). Een analyse van categoriefouten die Nederlandse kinderen tussen 2;6

(2 jaar; 6 maanden) en 3;6 maken in hun spontane taalproductie liet zien dat zulke fouten enorm zeldzaam zijn (§3.2). De ideeën die Marantz (1997) en Borer (2003) presenteren over syntactische representaties van verba en nomina die onafhankelijk van de lexicale ontwikkeling bestaan, worden niet bevestigd door deze data. Het kan echter wel zo zijn dat hun zienswijze geldt voor een eerder stadium van verwerving. Een longitudinale analyse van spontane productiedata liet vervolgens zien dat zodra kinderen woorden combineren tot zinnestjes, ze deze woorden ook gebruiken zoals volwassenen ze zouden gebruiken (§3.3). Hierbij moet wel opgemerkt worden dat het vaak moeilijk was om deze volwassenachtige productiepatronen goed te interpreteren, omdat er meerdere factoren door elkaar heen spelen. Zoals ik heb laten zien in §3.2.1 en met het voorbeeldje ‘dat is trekker’ (voorbeeld (5) in §3.3.2) is de morfologische kennis van de geanalyseerde kinderen nog in ontwikkeling en is het erg moeilijk om het weglaten van functiewoorden te onderscheiden van de kennis over categorieën. Omdat grammaticale markeerders nodig zijn voor het bepalen van de syntactische categorie van een woord waren veel uitingen, vooral van tweejarigen, onduidelijk qua categorie. Eventuele ontwikkelingsstappen werden door deze interpretatieproblemen versluierd. Daarom moest ik concluderen dat de vraag hoe kinderen verba en nomina leren niet afdoende kan worden beantwoord aan de hand van spontane productiedata. Wat wel kon worden geconcludeerd is dat tweejarige Nederlandse kinderen al categorieën van verba en nomina hebben die enige syntactische informatie bevatten.

Samengevat ziet het plaatje van categorieverwerving dat naar voren komt uit deze productiestudies er als volgt uit. Nederlandse kinderen weten al behoorlijk vroeg wat verba en nomina zijn, in die zin dat ze deze categorieën correct kunnen gebruiken in zinnen. Wat niet bepaald kan worden is of hun representaties van verba en nomina discreet en uniek gedefinieerd zijn, of prototypeachtig met onduidelijke grenzen. Vier van de theorieën uit hoofdstuk 2 maken precies deze voorspelling voor kindertaaldata. Baker (2003) voorspelt volwassen productiepatronen om dat de categorieën V en N aangeboren zijn. Hengeveld (1992b; Hengeveld & Mackenzie, 2008) voorspelt volwassen productiepatronen, althans kwalitatief, omdat kinderen aan de linkerkant van de hiërarchie beginnen met het uitdrukken van syntactische functies met inhoudswoorden en zo altijd binnen de mogelijkheden van de volwassen grammatica blijven. Croft (1991, 2000) en Goldberg (1995, 2006) voorspellen volwassen productiepatronen omdat de categorieën langzamerhand ontstaan op basis van de inputpatronen die kinderen waarnemen. De ene algemene voorspelling die op basis van deze vier theorieën geformuleerd kan worden, is bevestigd door de data. Kinderen gebruiken verba en nomina in een vroeg stadium van zinsproductie conform het volwassen patroon.

Wanneer en hoe Nederlandse kinderen verba en nomina waarnemen als verschillende categorieën

Het feit dat kinderen verba en nomina in hun productie verschillend gebruiken zodra ze woorden gaan combineren, laat zien dat talige categorisatie al begonnen is in een vroeg stadium, ook al is het niet precies duidelijk wat dit betekent behalve dat ze de vormen correct kunnen gebruiken. Om te onderzoeken wanneer en hoe categorisatie begint zijn Nederlandse volwassenen en het taalaanbod (input) van Nederlandse kinderen bestudeerd (hoofdstuk 4) en de voorspelling die uit deze studies volgden zijn getest met perceptie-experimenten (hoofdstuk 5).

Er zijn tenminste twee potentiële kandidaten voor aanwijzingen in de input die vroeg beschikbaar zijn en kunnen leiden tot categorisatie. Die twee kandidaten zijn de fonologische vorm en patronen in het samen voorkomen van woorden. De fonologische vorm van woorden is inderdaad een goede richtingwijzer voor categorie, want Nederlandse volwassenen blijken de fonologische vorm te gebruiken om te beslissen of een onzinwoord een nomen of verbum is (§4.2). Vier van de vijf generalisaties over de fonologische vorm van Nederlandse nomina (Trommelen, 1989) zorgden ervoor dat volwassen proefpersonen onzinwoorden als nomina categoriseerden, namelijk ‘echte’ bi-syllabiteit, een finale lange klinker, een finale schwa en een finale schwa gevolgd door [m]. Het bi-syllabische onzinwoord ‘meliens’ werd bijvoorbeeld door bijna 90% van de proefpersonen als nomen gecategoriseerd. Dit resultaat maakt het aannemelijk dat kinderen op een bepaald moment ook gebruik maken van de fonologische vorm om verba en nomina te herkennen. De methode die hier voor volwassenen is gebruikt, is niet bruikbaar voor het testen van kinderen. Perceptie-experimenten zijn mogelijk wel geschikt om deze voorspelling te toetsen. Omdat deze methode nog niet eerder gebruikt is voor fonologie, heb ik besloten om eerst een experiment dat al eerder voor het Engels was gebruikt om patronen van samen voorkomende woorden te toetsen, voor het Nederlands te repliceren, alvorens een heel nieuw experiment te ontwerpen dat de fonologische aanwijzingen toetst (maar zie §6.3 voor een idee van een dergelijk soort experiment).

Het specifieke patroon van samen voorkomende elementen dat ‘frequent frame’ genoemd wordt (Mintz, 2003) was de tweede potentiële kandidaat voor een aanwijzing voor categorisatie. De Nederlandse input bevat frequente woord frames die een aanwijzer zijn voor de categorie van de tussenliggende woordvormen. De categorie van woorden die tussen het frequente frame ‘wat X je’ liggen, is bijvoorbeeld een zeer accurate benadering van de categorie werkwoord in het Nederlands (gemiddelde standaard accuraatheidsscore: 0.99). Maar ook al zijn dit soort woord frames aanwezig in de Nederlandse input, ze bleken niet zulke

betrouwbare aanwijzers te zijn als in het Engels (§4.2). Toch was de verwachting dat Nederlandse kinderen ze wel zouden gebruiken om categorisatie te starten, omdat ze wel beschikbaar zijn. Tegelijkertijd was de suggestie dat kinderen zowel morfeemframes (bijvoorbeeld 'wat x -t') als woordframes zouden gebruiken, op het moment dat ze letten op alle lokale contexten van inhoudswoorden die frequent samen voorkomen in hun input.

De rol van frequente frames in vroege categorisatie is onderzocht met twee perceptie-experimenten (hoofdstuk 5). De resultaten van het eerste experiment laten zien dat frequente woordframes niet gebruikt werden door Nederlandse kinderen van 12 maanden en evenmin door die van 16 maanden. De conclusie moet luiden dat aanwijzers voor categorisatie verschillen per taal, want Mintz (2006) heeft laten zien dat Engelse kinderen van de jongst geteste leeftijd, 12 maanden, frequente woordframes wel gebruiken voor categorisatie. Een tweede experiment met Nederlandse dreumesen van 16 maanden liet zien dat ze wel degelijk frequente morfeemframes gebruiken voor categorisatie. De patronen van samen voorkomende morfemen in de input spelen dus een rol in de heel vroege ontwikkeling van categorisatie in Nederlandse kinderen. Het feit dat de patronen van samen voorkomende woorden door Engelse kinderen wel, maar door Nederlandse kinderen niet werden gebruikt laat zien dat de precieze aanwijzers verschillen per taal.

Deze resultaten bevestigen de uitkomsten van de productiestudies die hierboven beschreven zijn, namelijk dat kinderen verba en nomina herkennen als verschillende categorieën in de vroegste stadia van taalontwikkeling. Het categorisatiemechanisme maakt gebruik van input eigenschappen die beschikbaar zijn zodra het kind woorden en morfemen vanuit het spraaksignaal kan segmenteren. Dit onderzoek heeft laten zien dat Nederlandse kinderen morfeemframes gebruiken voor categorisatie. De categorieën gebaseerd op deze morfeemframes zijn perceptuele categorieën van woordvormen die op elkaar lijken. Het feit dat kinderen al met 16 maanden verba en nomina als verschillende categorieën waarnemen betekent dat ze deze categorieën onderscheiden voordat ze zinnen produceren.

Curriculum Vitae

Marian Erkelens was born on 5 May 1980 in Boskoop, the Netherlands. After obtaining her *VWO-diploma* from the *Gereformeerde Scholengemeenschap Randstad* in Rotterdam in 1998, she studied Linguistics at the Free University in Amsterdam. She took courses in both theoretical and applied linguistics and wrote her MA thesis on the acquisition of verbs for ‘cutting and breaking’ events by Dutch children. She received her MA on 2 October 2003 and after a short student assistantship at the Max Planck Institute for Psycholinguistics in Nijmegen she started as a PhD candidate at the Amsterdam Center for Language and Communication. In 2006 and 2007 she was also web editor at the same institute and teacher at the department of Dutch linguistics, teaching BA modules. For her PhD she continued working on first language acquisition, now studying how Dutch children learn to categorize verbs and nouns in general. This dissertation is the result of the research conducted during that time.