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Learning to categorize verbs and nouns : studies on Dutch

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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, than 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-months-olds; this work is in progress. Secondly, we can predicted 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 predicted 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.