FUNCTIONAL CATEGORIES IN EARLY LANGUAGE ACQUISITION: THE CASE OF DETERMINERS

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FUNCTIONAL CATEGORIES IN EARLY LANGUAGE ACQUISITION:
THE CASE OF DETERMINERS

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This dissertation explores the status of *Functional Categories* (FCs) - the grammatical categories that are realized in language by a closed-class set of *Function Words* (FWs; e.g., '*the*', '*and*') and bound morphemes (e.g., -*ed*, -*s*) - in children's early representation and processing of language.

Since FCs play a fundamental role in establishing the structural skeleton of sentences, a crucial question is when and how do children incorporate the functional lexicon into their representation and processing of language. On one view, children initially focus on content words such as nouns and verbs and on the basis of these infer meaning and reference. An opposing view is that FCs guide and facilitate the child's acquisition of language from the earliest developmental stages. Specifically, by serving as primary cues for word learning, word categorization and sentence computation purposes.

This research program investigated whether children may consult the grammatical role of FWs in sentences - in particular, *Determiners* - already at 1-to-2 years of age. In three experiments, 12, 18, and 24-month-old infants were tested on a preferential-looking task which contrasted grammatical sentences (e.g., '*can you see the ball?*'), versus three ungrammatical conditions in which the determiner '*the*' was either dropped, replaced by a nonsense word, or replaced by an alternate English FW ('*and*').

Both the 18- and 24-month-olds oriented faster and more accurately to target following grammatical sentences in comparison to the ungrammatical conditions. A group of 12-month-olds tested on the exact same task failed to show such differences. However, another group of 12-month-old infants who were first familiarized with the test nouns and their respective images, oriented faster to target following grammatical sentences in contrast to the two ungrammatical substitution conditions (*and/el*).

These findings demonstrate that already around the 1-year marker - although FWs are typically omitted from children's productive speech (in English) - infants incorporate syntactic information regarding FWs in sentence processing. This early grammatical sensitivity enables the syntactic categorization of words and facilitates reference determination. This suggests that both lexical (content) word categories as well as functional word categories are developing *in tandem* during these critical periods in language acquisition.

BIOGRAPHICAL SKETCH

Yarden E. Kedar was born and raised in Jerusalem, Israel. In 2000 he received his Bachelor of Arts degree in Behavioral Sciences from Ben-Gurion University of the Negev (Be'er Sheva, Israel). In 2001 he moved to Ithaca, NY to begin the Ph.D. program in Human Development at Cornell University. He received his Master of Arts degree in 2004 and his Ph.D. in 2007, both in Developmental Psychology.

To Vered

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LIST OF ABBREVIATIONS

CP –	Complementizer Phrase
DP –	Determiner Phrase
ERP –	Event-Related Potentials
FCs –	Functional Categories
fMRI –	Functional Magnetic Resonance Imaging
FWs –	Function Words
IP –	Inflectional Phrase
IPLP –	Intermodal Preferential Looking Paradigm
MCDI –	MacArthur-Bates Communicative Development Inventory
MEG –	Magnetoencephalography
NP –	Noun Phrase
PLT –	Proportion of Looking Time

SLI –	Specific Language Impairment
UG –	Universal Grammar

CHAPTER 1

INTRODUCTION

The scientific study of children's acquisition of language has progressed significantly in the last decades, ever since Noam Chomsky had first posed the field's main questions in the 1950's:

1. What is the essence of knowing a language? How is linguistic knowledge represented in one's mind?
2. How does the child reach this adult-level representation and mastery of language?

According to Chomsky, to explain the universality of language in the human species, a biologically programmed *Language Faculty* must be assumed (e.g., Chomsky 1965, 1986; 1988, 1995; 2000). This *Language Faculty* is realized by a *Universal Grammar* (UG), which is defined by Chomsky (1978) as ``*...the system of principles, conditions, and rules that are elements or properties of all human languages... the essence of human language"*. Consequently, in regards to the acquisition of language, a UG-guided developmental program, which specifies the sequence and timing for acquiring certain linguistic properties, is surmised (see Chomsky, 1986; Cook, 1988; Lust, 2006).

Chomsky's fundamental questions as well as his proposed solutions have challenged scholars in the fields of linguistics, psychology, biology, computer science, and various other areas. Nowadays, researchers use an array of methods and measures to explore the universal phenomenon of language use and acquisition in the human species, as well as the broader interrelations between language and other cognitive domains such as memory, *Theory of Mind*, among others.

Specifically, in language acquisition research, new measures such as (i) brain-imaging techniques; (ii) comparative cross-linguistic studies of children's acquisition of language in monolingual and multilingual communities; (iii) comparing normal versus abnormal language development (i.e., language disorders); and (iv) focusing on particular aspects of language such as phonology, syntax, semantics and pragmatics – have all led to an accumulation of new knowledge regarding children's mastery of language at different developmental stages (in fact, from prenatal stages and on).

1.1. *The Acquisition of Functional Categories*

This dissertation addresses a specific area in the language and cognitive sciences, namely, children's acquisition of syntax. This topic directly relates to Chomsky's fundamental questions since syntax is considered the driving force behind human languages. Specifically, syntactic rules are crucial for putting together words in a sequence to form phrases and sentences, and allow unlimited production and comprehension of new sentences with indefinite recursion (Lust, 2006). Therefore, documenting how the child masters this complex combinatorial system seems vital for understanding the general process of language acquisition, as well as the basic constituents of language in general.

Particularly within the domain of syntax, this dissertation examines one particular component - *Functional Categories* (FCs) - and its acquisition by young children.

Functional categories are grammatical categories that are realized in language by a limited (closed-class) set of *Function Words* (FWs; e.g., '*the*', '*and*', '*at*') and bound morphemes (e.g., -*ed*, -*s*, -*ly*). Functional elements in language typically carry little or no semantic value. In contrast, *Content Categories* (nouns, verbs, adverbs and adjectives) are realized by *Content Words*, which typically convey meaning rather than fulfill grammatical functions (e.g., ‘*ball*’, ‘*beauty*’, ‘*jump*’).

Although content words may seem more salient, current linguistic theory grants FCs a central role in language because they are critical in establishing the structural skeleton of a sentence. Namely, each of the basic FCs, such as *Determiners*, *Complementizers* and *Verb Inflections* - provides a phrase structure head for the basic phrase constituents of a sentence (e.g., Abney, 1987; Chomsky, 1995). Functional heads also create the basis for unit displacement in sentences by providing ‘landing sites’ to which phrase constituents may move (Lust, 2006). To acquire FCs, children must map specific FWs to their respective FCs (e.g., ‘*the*’; ‘*a*’ → *Determiner*). Thus, the child must at some point reach the adult-like representation and processing of FCs. That is, acknowledging FCs as abstract elements with a syntactic role in forming the phrase structure (i.e., with head and complement).

The role of FCs in early language acquisition continues to be debated, as two basic contrasting views compete to explain this mapping process. One view has taken children’s omission of FWs in their early speech as evidence that they are not yet aware of FWs as distinct units carrying a grammatical role. Instead, children are argued to access content words such as nouns and verbs and on the basis of these, infer meaning and reference in speech (e.g., Bowerman, 1973; Grimshaw, 1981; Macnamara, 1982; Pinker, 1982, 1984; Radford, 1990, 1997; Schlesinger, 1971, 1981; Tomasello, 2002). Different explanations have been provided for why FCs are absent from early periods of language acquisition. For example, gradual (biological) brain maturation (e.g., Radford, 1990, 1997), or general cognitive learning mechanisms (e.g., Tomasello, 2000a,b, 2002).

However, this general view has been challenged by ample empirical and cross-linguistic evidence that have demonstrated early detection of FWs in the speech stream in contrast to content words and to nonsense words.

Moreover, it has also been suggested that infants in their second year of life can distinguish different types of FWs based on their particular *grammatical* role in sentences (e.g., Bernal, Lidz, Millotte, & Christophe, in press; Christophe, Bernal, & Dehaene-Lambertz, 2006; Gerken & McIntosh, 1993; Höhle, Weissenborn, Kiefer, Schulz, & Schmitz, 2004; Kedar, Casasola, & Lust, 2006; Peterson-Hicks, 2006; Shady, 1996; Shady & Gerken, 1999).

1.2. *A New Research Program*

Based on the ongoing debate between the two views presented above, my primary goal was to investigate whether early access to the grammatical role of (English) FWs - in particular, the functional class of *Determiners* - may be present already between 1- and 2 years of age. Importantly, at this early developmental stage, infants do not typically demonstrate extensive overt production of FWs. By testing infants' sensitivity to specific FWs in the linguistic input, it is assumed that we can begin to determine how the young child faces the challenge of mapping specific FWs to their respective FCs and vice versa.

In a series of preferential-looking studies with 12-, 18, and 24-month-olds, it has been found that the infants could in fact detect ungrammaticalities that were caused by manipulating a single FW in a sentence. These findings are discussed in terms of their theoretical contribution to linguistic theory in general, and the field of language acquisition in particular.

1.3. *Overview of Dissertation Structure*

Chapter 2 surveys several theoretical approaches regarding the nature, typology, and role of FCs in language. For example, one debate regarding FCs is just *how* important these grammatical elements are for language representation and processing. According to one view, while specific FWs may specify and clarify some relations among content words in a sentence, FWs (and their respective FCs) are not crucial for conveying meaning and are only secondary to the content-carrying elements in language. Alternatively, as mentioned above, FCs may be considered the fundamental building blocks of human language, or the essential 'glue' that holds a sentence together, and which enables the syntactic organization of language.

Other sections in *Chapter 2* review the experimental literature on the representation and use of FCs, including evidence from the study of language pathology, artificial languages, pidgins and creoles, *inter alia*.

From these general issues in the study of FCs in language, I begin reviewing theoretical views as well as empirical evidence on the *acquisition* of FCs. As discussed in Lust (2006), language acquisition and linguistic theory are closely interrelated. Thus, studying children's acquisition of language allows us to "*test, verify and develop linguistic theory*", whereas linguistic theory aids us in forming scientific hypotheses about the child's linguistic competence. In *Chapters 3-7*, I discuss the interrelations between the general and acquisition-based findings regarding FCs, and the implications of these findings for linguistic theory.

Chapter 3 focuses on the different theoretical approaches to language acquisition. Such theories are tied to one of two basic 'families', based on whether they adhere to the principles of UG. Particularly, I compare the explanation which each of these theories provides to account for the apparent differences between children's and adults' grammatical competence regarding FCs. Each theory holds different predictions regarding the course of the acquisition of FCs, and the role that FCs may have in the early stages of language acquisition. The current work directly tests these predictions.

Chapter 4 reviews the empirical findings on the timeline in which FCs are acquired; the underlying mechanisms in this process; and how the child's acquisition of FCs interacts and relates to the acquisition of the general (content) lexicon.

Chapter 5 presents the rationale and design for this research program. In addition, I discuss some reasons for using the *Intermodal Preferential Looking Paradigm* (IPLP). For example, the IPLP allows testing younger infants than in 'classic' behavioral tasks; and enables the use of multiple measures to analyze infants' response to linguistic input.

Chapter 6 presents three preferential-looking experiments in which 12-, 18-, and 24-month-old infants heard sentences with a grammatical ['*the*' + *Noun*] combination, versus three ungrammatical conditions in which the determiner '*the*' was either –

(i) Dropped;

(ii) Replaced by a nonsense word ('*el*');

(iii) Replaced by another English FW ('*and*').

The third condition is the most critical condition since it contrasts two *English* FWs ('*the*' versus '*and*') which are both highly frequent in English but carry different grammatical roles. That is, these two English FWs belong to different types of FCs

(*Determiners* versus *Complementizers*, respectively). In the current design, only the determiner '*the*' was grammatically correct in the specific sentence structure tested (e.g., *can you see the ball*?).

The main finding which this dissertation reports, is that following the grammatical sentences (in contrast to the ungrammatical sentences), the 12, 18, and 24-month-old infants oriented faster and more accurately towards a visual target. Thus, the infants demonstrated early sensitivity to the grammatical role which certain English FWs carry, and their reliance on such awareness in syntactically processing sentences and in determining noun reference.

Chapter 7 discusses the theoretical implications of the current findings and how they may promote our understanding of –

(i) Children's representation and acquisition of FCs, and of language in general;

(ii) Experimental issues in child language. For example, comparing the effect which different measures and methods have had in language acquisition (in particular, infant) research;

(iii) How FCs are generally represented and processed in the (adult) mind and what their overall significance in human language might be.

In addition, I present a series of fundamental questions which remain open regarding children's acquisition and early representation of FCs. First, I point out several directions which seem necessary in order to generalize and validate the current findings. For example, employing cross-linguistic research and neurolinguistic methods for testing even younger infants; and testing infants' ability to incorporate additional types of FCs (i.e., other than *Determiners*) in the syntactic computation of sentences.

The ultimate purpose of these proposed studies is to generalize and validate the main argument which I am advocating in this dissertation, namely, that the 12- to 24-month-old infants who were tested on the current preferential-looking design did not only detect FWs in the speech stream, but also consulted FWs for –

(i) The syntactic processing of the test sentences;

(ii) Deriving some aspects of sentence meaning;

(iii) Establishing noun reference in different sentential contexts.

Next, I define and address the '*hard*' problems in exploring the status of FCs in the early stages of language acquisition. Most important, we must further our understanding of the exact *nature* of infants' performance on the current preferential-looking task (i.e., what exactly do infants detect regarding the grammatical role of FWs in sentences?); and of the dominant *mechanisms* that may bring about such early sensitivity to FCs in young children. Several ideas for further research which could tackle these '*hard*' problems are suggested.

CHAPTER 2

FUNCTIONAL CATEGORIES IN LANGUAGE

This chapter provides an overview of some of the main theoretical and experimental work that has been done in the study of FCs in language. Two lines of research are reviewed in detail. In one line of research, studies have been exploring the nature and typology of FCs across both spoken and sign languages in search of some universal patterns. A second line of research attempts to explain how FCs are mentally represented and processed on-line.

Basic Assumptions. The next sections review several theoretical arguments as well as empirical evidence for and against three central assumptions which this dissertation bears on. Specifically, the current work assumes that a distinction between *Functional* versus *Content* categories in language is critical for –

1. The mental representation of language knowledge;
2. The on-line processing of language;
3. *Linguistic Theory* – Specifically, the emphasis on the notion of a *Phrase Structure* (with a head and a complement) as an abstract syntactic element.

These assumptions also provoke the necessity to look at *Language Acquisition* data in order to help resolve them. Specifically, we may ask whether and in what form FCs are represented and processed by the child (i.e., is children's mental representation of FCs similar to that of adult speakers?).

Such evidence touches on some critical issues in the study of language in general and language acquisition in particular. For instance, what lies in the core of linguistic knowledge (e.g., UG principles?) and does this core component guide the acquisition of language? Are there universal properties for FCs? Are there possible hierarchies among FCs? Do children honor the syntactic phrase structure - in particular, the role of functional heads in phrases - in their on-line processing of language?

To begin answering these questions, the general review in *Chapter 2* is followed by a presentation of the theoretical and experimental work which has been done specifically regarding the *acquisition* of FCs (*Chapters 3-6*). In *Chapter 7*, I discuss the interrelations between the acquisition literature (including the current research program) and the general theories and findings regarding FCs – and their implications for the three general hypotheses that were mentioned above.

2.1. *Functional Categories: An Overview*

All human languages are assumed to have two basic grammatical categories: *Content* and *Function* word categories. Content categories[1] are comprised of nouns, verbs, adjectives and adverbs. Items from these categories are referred to as *content* (or *substantive*) words since they convey meaning rather than grammatical functions, that is, they refer to concepts, agents, entities and actions in the world. This class of words is often also called *open-class*, because languages relatively freely allow adding new content words to the lexicon (e.g., *email*; *I googled*; *blog*).

In contrast, *Functional Categories* (FCs) are expressed by *Function Words* (FWs; e.g., '*if*', '*but*', '*the*', '*was*') and *bound morphemes* (verb inflections such as -*ed*, -*s*, -*ly*)[2]. These grammatical items carry a structural role in language, and may be distinguished from content words based on several factors. Functional items are also called *closed-class* words because they form a limited class that hardly ever expands,

[1] Content categories are often called *Lexical Categories*; however, since functional word categories are also part of the lexicon it would be better to distinguish the two category types by their role in language.
[2] In this work I will use the term FWs to address both free and bound grammatical morphemes.

that is, a closed-class vocabulary. Interestingly, neologisms are strictly constrained to open-class items (e.g., '*to google*'; '*email*'; '*blog*'). No functional neologisms are ever reported in the speech of normal adults (Stromswold, 1994), aphasics (Lecours, 1982), or children (Pinker, 1994), thus marking a first division in our access and use of these two word category types.

Furthermore, although languages may vary considerably in the types of FCs and FWs they use – it has been generally shown that across languages, as well as within a language - FWs typically share some common acoustic and distributional characteristics (compared to content words). For example, FWs are often are monosyllabic and compose a small set of phonemes; extremely frequent in speech; tend to receive weak stress; may undergo cliticization (i.e., be attached to other words); and exhibit unique prosodic and segmental properties (Demuth, 1992; van Gelderen, 1993; Gerken, Landau & Remez, 1990; Shafer, Shucard, Shucard & Gerken, 1998; Shi, Morgan, & Allopenna, 1998).

Researchers in the areas of mathematical and computational linguistics have compared the relation between these two word classes (e.g., content words and FWs) as the relation in algebra between variables and operations, respectively. Hence, by using a set of fixed, 'primitive' operational units (FWs), speakers are able to highlight specific relations between the objects and actions (content words) (e.g., Hausser, 2001; Marcus, Păun, & Martín-Vide, 1998; Martín-Vide, 1997; Pullum & Gazdar, 1982). Another useful analogy is the relation in a musical score between the notes (content-carrying units) and structural elements such as clefs and time signatures.

Function words are considered 'functional' because they carry little meaning (have no synonyms), and typically only illustrate the relations between content words by specifying or constraining the meaning of words (e.g., '*he talks*' vs. '*he talked*'), phrases (e.g., '*the dog*' vs. '*a dog*') and sentences (e.g., '*she came to the boat*' vs. '*she *will come <u>in</u> <u>a</u> boat*'). Thus, FWs contribute to the overall meaning of sentences but their meaning cannot be explained based on objects or actions. That is, FWs do not refer to concrete entities themselves and the correlation between the occurrence of specific FWs and certain objects or actions is very low (Pulvermüller, Lutzenberger, & Birbaumer, 1995).

2.2. *Defining and Classifying Functional Categories*

In general, FCs are typically classified into three main types[3]:

1. CP – *Complementizer Phrase* in which a complementizer (e.g., *if*, *that*, *for*) or a conjunction (e.g., *and*, *but*) heads a sentence or a clause complement.
2. DP – *Determiner Phrase* in which a determiner (e.g., *the*, *a*, some) heads a noun phrase complement. Valian (1986) suggested that in order to be included in this word category, items must occur only before a noun or an adjective, and in addition must not be sequenced or be the sole content of an utterance.
3. IP – *Inflectional Phrase* in which an inflector (e.g., *was*, *will*) heads a predicate (or a clause). The IP encompasses the inflection features of the sentence's main verb.

These grammatical categories are now assumed to serve as the heads of syntactic phrases, to construct (or 'glue') the structural skeleton of sentences, and to allow some essential syntactic operations in the computation of language such as movement and agreement (e.g., Abney, 1987; Bowers, 1987; Chomsky, 1995, 2000; Cinque, 1999; Hellan, 1986; Lust, 2006; Reuland, 1986)[4].

[3] Some researchers also include in this group the *Preposition Phrase* in which a preposition (e.g., '*under*', '*to*', '*from*') precedes a Noun Phrase. However, in this dissertation I assume the minimal set of FCs. That is, CP, IP and DP, which correlate with the basic syntactic and semantic components of a sentence (i.e., the clause, *Verb Phrases* and *Noun Phrases*, respectively).
[4] See the next section for a detailed account of how FCs are perceived in current syntactic theory.

However, a debate regarding the specific nature, typology and number of FCs in language continues (e.g., Belletti & Rizzi, 1996; Chomsky, 1995; Cinque, 1999; Kayne, 2005; Pollock, 1989; Rizzi, 2004). For example, it has been questioned whether TP (*Tense Phrase*), AgrSP (*Subject Agreement phrase*), and AgrOP (*Object Agreement phrase*) should each be considered a separate category, or whether these phrase types are all parts (i.e., features) of IP.

Moreover, the realization of FCs is considerably different across languages. Consequently, the comparative study of human languages has shown that defining which FCs are present in each language, understanding how these FCs are realized in the language, and finding universal commonalities in FCs across all languages, is neither a simple nor a completed task.

As will be more broadly discussed in *Chapter 7*, such questions and debates also challenge the theoretical and empirical work on the *acquisition* of FCs. That is, what exactly the child is expected or assumed to ultimately acquire regarding FCs, may vary considerably among researchers based on one's theoretical view on how FCs are represented in the *Language Faculty*, or what their shared universal properties (if any at all) must be.

2.2.1 *Determiners as a Functional Category*

Since this dissertation focuses on the acquisition of *Determiners*, let us examine the definition of *Determiners* as a functional word category (with articles as a sub-category). The hypothesis that FCs are an essential part of all human languages, or more specifically, that *Determiners* form a FC - may run into a problem in the face of many 'determiner-less' languages. Thus, while in English, for example, the *Determiner* class includes the articles '*the*', '*a*' and '*an*', other languages such as Hebrew have an equivalent definite article to '*the*', but not to the indefinite articles '*a*' and '*an*'; whereas other languages such as Cantonese or Latin seem to lack articles entirely (as well as many other determiner-like elements).

Linguists have come up with opposing explanations for this issue. According to *The Covert Determiner Hypothesis*, determiners might be projected and stay covert next to other determiner-like elements. For example, in Cantonese: demonstratives, classifiers and numerals (Chan, 1999). Similarly, Progovac (1998) argued for an empty determiner slot in Serbo-Croatian – which is another language that does not use articles overtly.

In contrast, *The Noun Phrase Hypothesis* states that there is no DP structure in article-less languages. Hence, nouns only project to NPs, with the functional elements constructing a classifier phrase. The classifier heads a *classifier phrase*, which serves in turn as the specifier of the head noun. Similar proposals exist regarding other types of FCs across languages. Such proposals thus posit a scientific challenge of finding a common basis to account for the many differences in the representation and realization of FCs cross-linguistically.

2.2.2. *No Functional Categories?*

Some researchers have come up with even a more radical claim, which challenges the basic idea according to which FCs are an integral part in all human languages, with some basic shared properties (e.g., Culicover, 1999; Costa & Gonçalves, 1999; Hudson, 1998; Pereltsvaig, 2001).

For example, Hudson (1998) argues against the notion '*Functional Category*' as pertaining to a universal word-class, but accepts that individual words may be described as FWs or content words. Focusing on two of the least controversial examples of FCs – DP and CP – Hudson claims: *"…neither of these categories is needed (for understanding and using language) and that there is even less* *independent support for the more abstract FCs like inflection and its subtypes"; "…there is no word-class of 'Determiners', because Determiners are simply 'transitive' pronouns; nor do 'Complementizers' comprise a word-class because the standard Complementizers are all different from each other".* Analyzing the structure of FCs in Portuguese, Costa and Gonçalves (1999) reached similar conclusions.

Other researchers have questioned whether different factors, rather than the Content Word versus Function Word distinction, may serve as better criteria for lexical classification. For example, one way of dividing and classifying the lexicon is by focusing on the *semantic* information a word carries in a specific context (e.g., words like *in* and *on*, although commonly defined as FWs, often do carry significant semantic information). Alternatively, it has been suggested that the lexicon (in any language) should also be classified based on phonological or distributional factors such as word length and word frequency rather than only on syntactic word classes (see Bird, Franklin & Howard, 2002; Friederici, Meyer, & von Cramon, 2000a; Friederici, Opitz, & von Cramon, 2000b; Kutas, 1997).

These ongoing debates are important since they advance our understanding of the nature and typology of FCs across languages, and consequently, capable of challenging our hypotheses on what may be the mental representation of FCs in the *Language Faculty*. However, while acknowledging that further research is needed to better define what is shared between languages regarding FCs and what is open to variation - this dissertation does follow the common view according to which FCs are linguistically and psychologically 'real'. That is, it is accepted here that FCs are indeed grammatical categories that play a crucial role in enabling the basic structures (e.g., phrase structure) and operations (e.g., movement, recursion) in language; and which seem to be at the core of linguistic knowledge. The next sections provide further theoretical arguments and empirical evidence for this view.

2.3. *Functional Categories under the Universal Grammar Framework*

Current linguistic theory is dominated by a philosophy of universal principles in language – a *Universal Grammar* (UG). Some major principles of UG are (see Cook, 1988; Lust, 2006):

1. *Structure Dependency* - All operations on sentences are defined in terms of phrase structure hierarchy (rather than linear sequence for example).
2. *The Head Parameter* **-** Each phrase contains a head (main word), and the head in all phrases in a given language is consistently in the same position. The head position changes however from language to language. This introduces the important concept of a parameter-governed rule.
3. *The Projection Principle* **-** Properties of lexical entries project onto the structure of the phrases of which they are the head. This rule ensures for example that a verb gets the appropriate number and type of objects.

In the early versions of the *UG Standard X-bar Theory*, the definition of *Noun Phrases* (NP) described them as single-headed constructions with a noun as the head, while other elements in the NP such as complements, modifiers and specifiers were only secondary to the head noun.

However, the *Extended X-Bar Theory* and *The Minimalist Program* overturned this hierarchy and focused instead on FCs as the heads of sentences (CP), clauses (IP) or noun phrases (DP) (e.g., Abney, 1987; Bowers, 1987; Chomsky, 1986, 1988, 1995, 2000; Hellan, 1986; Reuland, 1986). Linguistic theory now grants FCs a central role in the language faculty as the heads of their own projections. That is, functional heads are marking and heading each of the basic constituents in a sentence, thus establishing the structural skeleton of sentences (see Chomsky, 1986, 1995; Lust, 2006). For example, under this view, in the English sentence "*the little boy was jumping*", the determiner '*the*' is the head of the Noun Phrase '*little boy*', hence forming a *Determiner Phrase* (DP) - "*the little boy*"; whereas the auxiliary '*was*' serves as a head for the *Verb Phrase* (*jump*), hence forming an *Inflectional Phrase* (IP)[5].

The acquisition and use of FCs has consequently become a crucial research area under the UG framework since according to Chomsky, especially as presented in his *minimalist* theory (Chomsky, 1995), most language-specific properties are expressed through this component of the syntax. In addition, FCs are considered critical in setting cross-linguistic parametric values such as word order variation (e.g., Hyams, 1986; Lebeaux, 2000) and in allowing recursion (Lust, 2006).

2.4. *Explaining the Cross-Linguistic Variation*

Given the current conception of FCs as the building blocks of language, it has been proposed that much of the variation in FCs among languages can be accounted for by differences in the way FCs are represented and organized in a specific language, or in other words, by the different *parameter settings* which different languages have for FCs. As mentioned above, researchers have typically attempted to reach a comprehensive, descriptive account of which functional elements are used across different languages, as well as providing an explanatory model, that is, a model which can account for the differences in the cross-linguistic realization of FCs, and which could demonstrate how all of these are related on some general, abstract level.

Take for example the way in which languages differ in regards to grammatical morphemes (see Kayne, 2005). Some morphemes are considered *free* morphemes

[5] In contrast, other researchers claim that the DP analysis fails to capture phrase structure in languages with no determiners or with only affixal determiners. Thus, in such cases it is claimed that the noun serves as the head for the nominal projection (e.g., Kolliakou, 2004 - Modern Greek; Zlatic, 1997 – Serbian).

(e.g., in English - prepositions like *under*, *to*, or *of*). Another type of grammatical morphemes involves *bound* morphemes, which are always attached to some other morpheme. Bound morphemes are generally divided into four sub-groups:

1. *Bound Bases*: Elements that seem to be the base, but which do not occur as free lexical morphemes (e.g., *-ceive, -duce, -ept, -cest*).
2. *Derivational Morphemes 1* - changing word meaning (e.g., *re-, pre-*).
3. *Derivational Morphemes 2* - changing the part of speech (word class) of a word (e.g. *–ish, -ment, -ness, -al*).
4. *Inflectional Morphemes* - signaling a grammatical relationship such as tense, aspect, number or case.

Importantly, some languages (like English) use both kinds of grammatical morphemes (free and bound), while others do not. Such accounts, which attempt to explain how languages differ in the use of FCs, are critical for proponents of a UG-governed, language-specific faculty in the human mind, since they seek a single structure which applies to all possible variations in FCs across languages. Moreover, these accounts seem important in order to define the exact task that children are facing in learning specific FWs as well as mastering the FC system in their language – as will be discussed in *Chapter 3* below.

2.5. ***Historical and Evolutionary Proposals for the Origin of Functional Categories***

How did FCs evolve to be an integral part of human languages? One view is that functional and content elements were interrelated from the very early stages in which human beings developed language. Under this view, functional elements were equally important to content elements in the evolution of language. A more common proposal is that grammatical elements were created only after a basic lexicon of content words was created (e.g., Wunderlich, 2004).

It has also been proposed that FCs not only followed content words in time, but that functional elements are in fact derived from content items such as nouns, verbs and adjectives. For example, Greenberg (1987) suggested that determiners and quantifiers may have originated in adjectives. According to Givon (1981), definite determiners were developed out of demonstrative adjectives whereas indefinite determiners come from numeral adjectives relating to the concept of '*One*'.

Thus, the field of historical linguistics gives us some insights on the status of FCs in language, even though obviously direct evidence for these proposals could never be found (i.e., spoken language leaves no physical traces). The next sections (as well as *Chapter 4*) review other research directions - in particular, *Language Pathology*; *Pidgins and Creoles*; *Artificial Languages*; *Psycholinguistics*; and *Language Acquisition* – which may shed light on these questions.

2.6. *Functional Categories in Language Pathology*

A variety of language disorders exists, such as aphasia, *Specific Language Impairment* (SLI), language breakdown as result of brain injury or disease, and other cases in which language is not used and acquired in a normal way.

As Jakobson (1971) pointed out, a number of correlations between (normal) child language and aphasic speech exist. According to Jakobson, we can gain knowledge from deficient linguistic communication at least as much as when language functions normally. Specifically regarding the role of FCs in language, some language disorders have been linked to deficits in representing and using FCs. Hence, the study of different cases of language pathology may be proven useful for understanding the role and acquisition of FCs in normal populations as well.

2.6.1. *Genie*

One extreme example of language pathology is the well-known case of '*Genie*', the 'modern-day wild child' who was kept in isolation until the age of 11 (Curtiss, 1977). This tragic case of abuse and neglect illustrates on one hand the endurance of language, but also highlights the crucial part which syntax plays in attaining efficient communication abilities. Genie's language skills did develop to some extent, but her utterances were limited syntactically.

Specifically, Genie was able to learn individual words and signs and sometimes followed the basic word order (e.g., "*Want milk*"; "*Mike paint*"; "*Big elephant*"; "*Applesauce buy store*"), but performed poorly on pronouns, movement rules, passive constructions, and auxiliaries. Importantly, Genie's speech lacked functional elements and consequently her language ability was severely impaired. Genie's difficulties in using syntax in general and FCs in particular again illustrate the importance of these elements in normal human language.

Genie's case demonstrates just how important certain components of language (e.g., syntactic structures) may be for the normal use of language. The next sections review several other, more common cases of language breakdown in which a person is not able to produce or comprehend language normally - and focus on the status of FCs in such cases.

2.6.2. *Functional Categories in Language Disorders - Empirical Findings*

There is some evidence for a double dissociation between impairments involving content words versus FWs in both acquired and developmental language disorders. Some neuroscience findings suggest that the agrammatic comprehension deficit of *Broca's* aphasics involves a delayed or incomplete availability of word-class information (See Stromswold, 1994).

Specifically, FWs are typically absent or are used ungrammatically in these aphasics' speech while content words are used relatively normally (e.g., Goodglass, 1993; ter Keurs, Brown, Hagoort, & Stegeman, 1999). In contrast, *Wernicke's* 'jargon' aphasics typically master FWs relatively well, but face great difficulty in dealing with content words (e.g., Lecours, 1982; Stromswold, 1994). These contrasting states suggest that FCs are represented differently and accessed independently in comparison to content categories.

Other studies have used agrammatic populations and case studies to test the hypothesis that FCs are linked in hierarchical structures (trees), from subordinate categories (lower) to super-ordinate (higher) categories, and trigger verb movement stepwise from subordinate to super-ordinate categories (e.g., Chomsky, 1995; Izvorski & Ullman, 1999). Researchers have tested whether higher projections would be particularly impaired in agrammatism under the assumption that fewer movement operations are necessary when computing lower rather than higher categories (i.e., lower category → easier to compute).

One example is a recent study (Bottari, Cipriani, Chilosi & Pfanner, 2001) on the acquisition of Italian determiners by normally developing children, a child recovering from childhood aphasia, and children with SLI. Based on the view that *Determiners*, unlike other FCs, are base generated, Bottari *et al*. (2001) claimed that DP mastery should involve less computational load than the mastery of other FCs that are subject to syntactic operations such as movement or feature checking. Results from Bottari *et al*.'s (2001) study and others do seem to show that this is the case, although clearly this is not the only factor in agrammatism (e.g., Caplan, 1996; Grodzinsky, 1990; Izvorski & Ullman, 1999).

2.7. *Pidgins and Creoles*

Pidginization and creolization are two phenomena that can also shed light on some basic questions regarding FCs:

(i) How did FCs evolve (historically and/or biologically)?

(ii) How does the child acquire FCs?

According to deGraff (1999), pidgins are basic and simplified systems, without native speakers, and used in functionally restricted contexts of interethnic communication, whereas creoles are pidgins which have become the native language of a speech community. Typically, pidgins and creoles arise in situations involving "*population displacements, plantation economies, slave trade, indentured labor, commercial trade, interethnic exchanges, and the like*" (deGraff, 1999).

A major difference between pidgins and creoles is that pidgins seem to lack FCs, whereas in creoles the second generation of speakers (i.e., children) has often already developed functional structures (Bickerton, 1981; Romaine, 1988). Thus, soon after a mix of cultures and languages occurs, the minimally developed pidgin becomes a creole that is equivalent to other languages with its own full-fledged grammatical rules, and in particular, with functional heads governing its syntactic structure.

This phenomenon, in which the second-generation children transform the pidgin code into a full language, occurred similarly across many different social circumstances and geographical areas, with the emerging creole operating along the lines of the UG principles and the newly invented FCs showing the universal pattern of DP, CP, and IP (Bickerton, 1981; deGraff, 1999). If children who do not get a syntactic model for the new language (i.e., the creole) are still able to develop a syntactic system of their own - FCs must be important for language (rather than a ‘stylistic’ addition). Furthermore, a long cultural process of gradually building a functional lexicon is not necessary and seems unlikely given the rapidity in which functional elements are incorporated into the creole. Instead, FCs and FWs seem mandatory for making a pidgin into a functioning, complete language.

2.8. *Created Sign Languages*

Other examples, which are similar to the pidgin-creole phenomenon, seem to provide even stronger evidence for the conclusions given above. These are the cases in which deaf children, who were not exposed to any sign language model, have nonetheless created their own language (e.g., Goldin-Meadow & Feldman, 1977; Goldin-Meadow & Mylander, 1998; Goldin-Meadow, Mylander, & Franklin, *in press*; Senghas, 2000). These cases seem to overcome perhaps the biggest methodological constraint in language acquisition research, that is, children’s continuous exposure to rich linguistic stimuli, which makes it hard to distinguish innate knowledge specific to language from more general learning and cognitive skills. Such cases also differ from the ‘from-pidgin-to-creole’ examples where children are not entirely derived of language experience since they normally acquire their parents’ native language, and so could have transferred some of the syntactic characteristics of their parents’ language to the creole.

Self-made sign languages have been reported to include both content and functional elements and to operate similarly to other sign and spoken languages. The work of Goldin-Meadow and her colleagues was first to document the linguistic creativity that deaf children have used to convey meaning (i.e., *Home Signs*; See Goldin-Meadow & Feldman, 1977; Goldin-Meadow & Mylander, 1998).

In a recent study, Goldin-Meadow, *et al*. (in press) have reported that home-signing children, who did not get any linguistic input, have nonetheless spontaneously developed a set signs which serve as grammatical (i.e., functional) morphemes.

Lastly, the well-known story of the emergence of the *Nicaraguan Sign Language* (see Senghas, 2000) is another example for individuals independently creating a complete and complex *language* with no full model – including an entire set of functional elements in the form of spatial modulations.

2.9. *Experimental Studies on the Representation and Use of Functional Categories*

Many studies have explored the representation and use of FCs in *adult* subjects using a variety of research designs and methodological approaches. The current section summarizes some of the main findings yielded by these experimental endeavors.

2.9.1. *Word Processing Experiments*

Psycholinguistic research based on corpus analysis of speech errors and on studies which have used reaction time measurements of visual word processing raised the possibility that there is a specialized access mechanism for FWs during comprehension - as well as a general mechanism shared with content words (see Bradley & Garrett, 1983; Garrett, 1976). In such studies, lexical decision times were typically dependent on a word's lexical frequency in response to content words - but not in response to FWs - hence implying that the two word classes may be processed by different mechanisms (Bradley, Garrett, & Zurif, 1980)[6].

[6] But see Gordon & Caramazza (1982, 1985) for conflicting results.

2.9.2. *Artificial Languages*

Several researchers have tested the computation of FCs by using artificial languages (e.g., Green, 1979; Saffran, Aslin & Newport, 1996; Gomez & Gerken, 1999, 2000). The main advantage in such studies is that the researchers can control their subjects' exposure to the linguistic input (e.g., by deciding how many items of a particular type a subject would hear).

The use of an artificial code also enables simplifying or emphasizing certain aspects of the language, and testing subjects' computation of specific elements in a language, which they do not know. For example, we can test how fast subjects learn to recognize patterns between words, which mimic the relations between FWs and content words in real languages. Specifically, studies using artificial languages have demonstrated that adult subjects experienced difficulty in mastering an artificial linguistic code if the items which served as functional elements were omitted; or when the ratio between function and content words was different from the ratio found in natural languages, that is, FWs being much more frequent than content words (e.g., Cutler, 1993; Frigo & McDonald, 1998; Gomez & Gerken, 2000; Gomez & LaKusta, 2004; Green, 1979; Valian & Coulson, 1988).

2.9.3. *Neurolinguistic Inquiries*

Neuroscience methods such as *Functional Magnetic Resonance Imaging* (fMRI), *Positron Emission Tomography* (PET) and *Event-Related Potentials* (ERPs) examine *in vivo* the relation between cognitive processes and neurological patterns in the brain, thus extending knowledge driven from behavioral and lesion studies. Specifically regarding FCs, neuroscience techniques have been used to search for a distinction between the two word classes (i.e., *Function* versus *Content*), with the underlying assumption that such a distinction, if found, would help answer the questions of *if*, *where*, and *how* syntax and semantics are separated in the brain (e.g., Brown, Hagoort, & ter Keurs, 1999; ter Keurs *et al*., 1999; Osterhout, Allen, & McLaughlin, 2002; Pulvermüller *et al.*, 1995).

2.9.3.1. *Temporal Findings*

The ERP method is a noninvasive brain imaging technique based on continuous recordings of brain activity originating from electrodes placed on the scalp. The recordings are time-locked to a visual or auditory stimulus and represent the summed electrical activity of synchronously activated clusters of pyramidal neurons within the cortex (see Coles & Rugg, 1995). Spontaneous background *electroencephalogram* (EEG) fluctuations, which are random relative to when the stimuli occurred, are averaged out. For this reason, ERPs reveal with high temporal resolution only the patterns of neuronal evoked by specific stimuli and capture the exact (millisecond-by-millisecond) time course of the cognitive function under study.

2.9.3.1.1. *Temporal Differences between Syntactic and Semantic Processing*

Several ERP studies have now been conducted in search differences in how syntactic versus semantic input are processed in the brain (Pulvermüller, 1999). These studies have generally provided evidence in favor of a functional differentiation in the brain between syntax and semantics. Specifically, a temporal model of syntactic and semantic brain processing has been proposed (Friederici, 1995; Friederici *et al*., 2000a,b; Hagoort, 2003; Hagoort, Wassenaar, & Brown, 2003; ter Kerus *et al*., 1999). According to this model, in an early stage, syntactic phrase structure is processed resulting in a left-anterior negativity (*LAN*, between 100–500 ms). Within this time window, an early *LAN* (*ELAN*) correlates with rapidly detectable word category errors whereas the following *LAN* correlates with morpho-syntactic errors. Next, a lexical-semantic integration stage produces a negative component, the *N400*. Lastly, syntactic and semantic information is combined and reanalyzed to achieve interpretation. This results in a broad symmetric late positivity peaking between 600-800 ms (*P600*).

2.9.3.1.2. *Processing Differences between Function Words and Content Words*

Apart from testing for a general semantics-syntax difference, some studies have specifically contrasted function versus content words. In several ERP studies (using both visual and auditory tasks) it has been found that the processing of function versus content words differs in three components.

First, during an early time window, approximately around 200–350ms, FWs elicit a left anterior *N280* component. In contrast, content words have been reported to elicit no early response at all; a less distinct negativity; or a delayed negativity (e.g., Brown, *et al*., 1999; King & Kutas, 1998; Neville, Mills, & Lawson, 1992; Nobre & McCarthy, 1994)[7].

In the same time-window, around 350-400 ms from stimulus onset, a significantly larger posterior negative component in response to content (than function) words occurs (e.g., Kutas & Hillyard, 1983; Neville, *et al*., 1992; Nobre & McCarthy, 1994; Osterhout, McLaughlin, & Bersick, 1997; Pulvermuller, *et al.*, 1995). This has generally been assumed to reflect online lexical-semantic integration processes related to the insertion of word meanings into the sentential and discourse context (e.g., Brown, *et al*., 1999; Holcomb, 1993). Although FWs also produce an *N400*-like negative response, it is typically weaker and its scalp topography does not

7 However, other studies (e.g., Osterhout *et al.*, 1997; Van Petten & Kutas, 1991) found no evidence for the left anterior *N280* component in response to FWs (and separate from the *N400*). In other cases, the *N280* was present following both word classes (Kutas & Hillyard, 1983; Pulvermuller *et al.*, 1995).

seem to match the standard *N400* distribution (e.g., Munte, Wieringa, *et al.*, 2001; Neville *et al.*, 1992)[8].

In a later time-window, approximately between 400- and 700 ms, FWs - but not content words - elicit a broad frontal negative shift largest over the left hemisphere: The *N400-700*, or *BNS* (e.g., Brown *et al*., 1999; King & Kutas, 1998; Kutas & Hillyard, 1983; Neville *et al*., 1992; Osterhout *et al*., 1997; Van Petten & Kutas, 1991). The *N400-700* (*BNS*) is assumed to reflect anticipatory processes in online sentence parsing that are associated with the distributional and syntactic nature of FWs. That is, FWs serving as phrasal heads which cue the beginnings of phrases and sentences (e.g., Brown *et al*., 1999; ter Keurs *et al*., 1999; Van Petten & Kutas, 1991). Moreover, in contrast to content words, which elicit a symmetrical negative peak at *N400* that is dominant over the posterior cortex, for FWs the size of this component is reduced and its scalp topography does not match the standard *N400* distribution.

2.9.3.2. *Spatial Findings*

Studies using *Magnetoencephalography* (MEG) and fMRI have found that frontal and temporal areas in the brain are primarily associated with syntactic processing. Spatial differences specifically regarding the comparison between content versus functional categories are also reported. For example, Newman *et al*. (2001) claimed that syntactic (versus semantic) violations lead to greater activation in the superior frontal cortex (bilaterally), the right anterior superior temporal sulcus, and the left Sylvian fissure, whereas semantic violations cause greater activation in the left hippocampal and para-hippocampal gyri.

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[8] However, Van Petten & Kutas (1991) and Munte *et al* (2001) claim that both word classes generate the *N400*, and that no differences in response to the two word classes are substantiated neurologically.

Friederici and colleagues (e.g., Friederici *et al*., 2000a,b) have argued that early syntactic sentence-parsing processes occur in temporal brain regions (possibly the *Planum Polare*) as well as in fronto-lateral regions. When sentences used 'real' FWs but nonsense content words (i.e., conveying only syntactic information) - the mid-portion of the superior temporal gyrus and the frontal operculum were activated.

2.10. *Chapter Summary*

Chapter 2 surveyed some of the main theoretical and experimental attempts to define the nature, typology, role and importance of FCs in human language. Specifically, in order to demonstrate some possible difficulties and challenges in exploring how the *child* incorporates FCs in their acquired language's grammar, I have introduced several ongoing debates regarding the types and number of FCs across the world languages.

Thus, I have emphasized the critical need for a wide-ranging model which could account for the considerable differences in the cross-linguistic realization of FCs; and which could demonstrate how FCs are related on some general, abstract level. As discussed above, attaining such a model could also guide us in forming more specific hypotheses regarding the child's early representation and processing of functional elements in language. For example, which FCs should we expect the child to be representing? How would that change in accordance with the specific language that the child is acquiring?

In general, the literature review which was presented in *Chapter 2* indicates that FCs are key phrase structure constituents with a vital role in the mental representation and online processing of language. An important theoretical advancement regarding the status of FCs in language has been the shift that occurred in linguistic theory, which now grants FCs a central role in constructing the syntactic structure of sentences (e.g., Abney, 1987; Chomsky, 1995; Lust, 2006). That is, functional elements in sentences serve as the heads of syntactic phrases. These functional phrase heads carry a critical role in setting cross-linguistic parametric values such as word order variation.

I have also highlighted certain directions of empirical research, which relate to some of the theoretical questions regarding FCs. Specifically; research on language pathology has provided some evidence for a double dissociation between impairments involving content words versus FWs in both acquired and developmental language disorders. This suggests that FCs are represented differently and accessed independently in comparison to content categories.

Likewise, it has been also demonstrated that in the process of a (basic) pidgin becoming a creole, as well as in cases of created ('self-made') sign languages - children demonstrate that they are capable of creating a language, which includes both content and functional elements, and which operates similarly to other sign and spoken languages. Thus, functional word categories seem to be at the core of human language. That is, FCs are appearing in new (invented) linguistic codes almost instantly, even when no full model of the language is provided (e.g., the child transforming a pidgin - which typically lacks a functional lexicon - into a full-fledged, 'real' language with a typical set of FCs and FWs).

In addition, the set of behavioral and neurolinguistic studies which were described above, provide empirical evidence (based on adult subjects) which demonstrates that content and functional elements (relating to semantics and syntax, respectively) are processed differently. These differences seem robust across a variety of populations (e.g., normal; aphasics; bilinguals); languages (English; German; Dutch); modalities (visual; auditory); and methodologies (e.g., visual and spoken word detection and sentence processing tasks).

Specifically regarding the neurolinguistic findings on FCs- and FWs processing – several ERP studies have demonstrated different temporal brain responses when processing FWs versus content words. In addition, spatial findings from MEG and fMRI studies have suggested that frontal and temporal areas are associated with syntactic (specifically, FWs) processing, and are different from other areas that are involved in semantic and content words processing.

2.10.1 *The Next Step*

I have attempted to illustrate that ample empirical evidence exists in support of the key assumptions regarding FCs which *Chapter 2* introduced. Thus, FCs are an integral part of -

(i) The mental representation of language;

(ii) The on-line processing of language;

(iii) *Phrase Structure* (i.e., serving as functional phrase heads).

Is this set of properties, which characterizes the adult representation and use of FCs, can also be apparent when we test the child? (and if so, at what developmental stage?).

An essential issue regarding children's acquisition of language is the extent to which the child's grammar differs from the (presumably fixed and finite) grammar of adult speakers. For this reason, the next chapters focus on the individual child acquiring a language. Specifically, in *Chapter 3* I present several theoretical approaches which have attempted to explain the nature and extent of the apparent differences between the child's and the adult's grammars in regards to FCs; as well as possible differences in the status of FCs at different developmental stages of child language.

CHAPTER 3

THEORIES ON THE ACQUISITION OF FUNCTIONAL CATEGORIES

3.1. *Overview*

A theoretical divide exists between a range of theories influenced by Chomsky's (1957, 1965, 1978, 1980, 1986, 1988, 1995, 2000) *Universal Grammar* framework, versus '*bottom-up*' or *learning* theories, which have originated from the behaviorist tradition.

In UG-based theories, the child's acquisition of language is guided by a set of universal principles, which are specifically related to language and which are part of our biological endowment. In learning-based theories however, no such innate knowledge of language exists. Instead, the young child is sensitive to the phonological, prosodic and distributional patterns in her language, and applies general cognitive (not language-specific) mechanisms to generalize these patterns into a full grammar. Infants are assumed to be gradually building their knowledge of language around frequent verbs and nouns that can be matched to concrete actions and entities in the infant's environment, and only later in development can generalize linguistic items and constructions into more abstract and adult-like syntactic categories.

Thus, according to learning-based theories, young children's processing of language is initially not structure-dependent (i.e., they are not based on phrasal constructions), but rather relies on specific words and expressions of meaning. Specifically regarding FCs, no knowledge of the possible types of FCs and how FWs may be structurally used in language is expected at the early stages of the acquisition of language (e.g., Tomasello, 2000a,b, 2002).

The UG-based theories also differ regarding the question of exactly when and how syntactic knowledge of language - and of FCs in particular - arises in the mind. The main questions these different versions of UG debate are:

(i) Is UG fully or only partially available to the child at the earliest stages of language acquisition?

(ii) What factors may explain the differences between child and adult speech (i.e., is child language qualitatively different from adult, 'final-state' level?).

Following are some of the main theoretical approaches to the acquisition of language and of FCs in particular.

3.2. *The Continuity (Full Competence) Hypothesis*

This approach states that all aspects of UG, including the functional architecture of language (e.g., CP, DP, IP), are available to the child and fully specified already at birth (e.g., Boser, Lust, Santelmann, & Whitman, 1992; Crain, 1994; Hyams, 1992; Lust, 2006; Poeppel & Wexler, 1993; Santelmann, Berk, Austin, Somashekar, & Lust, 2002; Weissenborn, 1990).

Continuity theorists have differed on how knowledge and experience may interact in the child's acquisition of language. Crain (1994), for example, presents a *Strong Continuity Hypothesis* according to which children adhere to universal principles of language during all stages of language development, and that although initially FCs may be phonetically null, the child nevertheless automatically detects the parametric values of the language she is exposed to.

According to another interpretation of continuity, the child's grammatical representations follow UG principles at all times, but only gradually map to the parametric values of the target language (e.g., Lust, 2006; Schaeffer & Matthewson, 2005; Weissenborn, 1990, 1991, 1992, 1994). According to Lust and her colleagues, the acquisition of language follows a *Grammatical Mapping Paradigm*. Thus, UG provides some general grammatical principles, and the child faces the task of matching the principles of UG to the grammar of the specific language she is acquiring (e.g., Boser *et al.*, 1992; Lust, 1999, 2006; Santelmann, *et al*., 2002)

Hypotheses under the continuity umbrella have also addressed specific functional structures. The *Universal Determiner Hypothesis* (see Penner & Weissenborn, 1996) asserts that the phrase marker of all (non-vocative) nominals includes a *Determiner Head*. Poeppel and Wexler's (1993) argued that (i) young children know the difference between finite and non-finite forms; (ii) movement involving targeted functional projections is available at early stages; and (iii) that the use of word order as seen in young speakers of German implies that IP and CP are available already at early stages[9].

In sum, according to the *Continuity Hypothesis*, children are born fully equipped with access to UG principles. The answer to why children produce sentences which may deviate from their native language grammar is explained mainly on the basis of the child's need to gradually trace and match the specific parameter configuration in her native language to the general UG principles, as well as other factors such as attention or processing limitations; perceptual/phonological characteristics of the specific language; and a deficiency in 'real world' semantic and pragmatic knowledge (e.g., Schaffer & Matthewson, 2005; Weissenborn, 1994; Weissenborn *et al*., 1998).

Another critical assumption under the *Continuity Hypothesis* is that although child grammar may depart from adult grammar, it is constrained to do so only in ways

[9] However, Wexler's (1994) later hypothesis of the *Optional Infinitive* stage seems to deviate from the continuity view.

in which languages actually differ from each other. This predicts that the child would never come up with grammars that possibly violate a principle of UG. Rather, the child's 'errors' can only contradict rules of the specific target language.

3.3. *Maturational Theories*

A critically different prediction - though still within the UG perspective - derives from a *maturational* view of language acquisition (e.g., Borer & Wexler, 1987, 1992; Clahsen, 1991; Deprez & Pierce, 1994; Felix, 1984, 1987; Lebeaux, 2000; Meisel & Müller, 1992; Ouhalla, 1991; Platzack, 1990; Radford, 1990; Tsimpli, 1991). The main argument under this view is that children's acquisition of language is guided by biologically-determined mechanisms. That is, while some UG principles are present at birth, others only mature with time and development.

Specifically regarding the status of FCs in early language, the child's grammar presumably lacks FWs during the initial phases of combinatorial speech because the modules of grammar that are associated with FCs need more time to mature in comparison to content categories and their projections.

Felix (1984, 1987) presented a strong version of this approach according to which the principles of UG are not fully available in early stages of language acquisition. Instead, these principles emerge successively, following a specific order which is pre-determined by a maturational schedule. Other researchers assert that even though some (or all) functional projections are missing at early acquisition stages, some (or all) of the UG principles are set. That is, the child's early representations of FCs and grammar deviate from the target language but are nonetheless guided and constrained by principles of UG (e.g., Lebeaux, 2000; Powers, 1996; Radford, 1990, 1997).

In his *Maturational Hypothesis*, Radford (1990) proposed that grammatical development is guided by a set of biologically predetermined stages. The child advances through a *pre-categorical* stage in which only single-word utterances are available, followed by a *lexical* stage in which content categories emerge, and only lastly the child reaches a *functional* stage in which FCs are incorporated. According to Radford, all functional projections, including CP, DP and IP, are absent in children's early grammar (see also Deprez & Pierce; 1994; Guilfoyle & Noonan, 1992; Tsimpli, 1991). Alternatively, Meisel & Müller (1992) have claimed that while functional projections with a lower location in the sentential hierarchy such as IP are initially present, higher functional projections such as CP are not. Another maturational view is that young children initially have a single, underspecified functional projection (Clahsen, 1991). Other versions of this argument are that functional projections are optionally present (Rizzi, 2004), or that they are present but are optionally underspecified (Wexler, 1994).

Such arguments for a gradual development in the representation of FCs are typically based on the absence of morpho-phonological elements related to functional projections in early speech. Studies which were mainly based on children's productive speech in English have found that children tend to omit FWs from their speech until around 2- to 3 years of age (see Bates, 1976; Bloom, 1970; Bowerman, 1973; Braine, 1976; Brown, 1973; Brown & Bellugi, 1964; Echols, 1993; Echols & Newport, 1992)[10].

Consequently, it has been often assumed that 'telegraphic-speaking' children are not yet aware of the grammatical role of FWs, nor do they classify specific FWs based on their respective FCs. For several researchers working along the lines of the

[10] Notice however that this line of evidence stems from studies testing English-learning children. Cross-linguistic research has provided different results regarding early production of FWs. This issue is further discussed below.

UG framework this suggested that access to specific FCs is either missing or only optionally exists in the initial stages of language acquisition, hence implying a maturational factor in the development of UG. For example, the lack of complementizers in young children's production of subordinate clauses has been interpreted as early absence of CP (Meisel & Müller, 1992). Similarly, the lack of auxiliaries, agreement markers and determiners has been interpreted as an indication that IP and DP are initially missing from children's grammar (Radford, 1990, 1997; Vainikka, 1993).

3.4. ***The Semantic Bootstrapping Hypothesis***

Lastly, *The Semantic Bootstrapping Hypothesis* focuses on the *Content Categories* as the dominant factor in early child language[11]. Thus, children presumably begin labeling the syntactic or semantic categories of words and phrases based on the objects, actions, and properties in the world to which the word or phrase refers (e.g., Grimshaw, 1981; Pinker, 1982, 1984; Schlesinger, 1971, 1981). Only once children have learned various lexical items, they become sensitive to FWs and change the basis of categorization from referential to distributional-grammatical.

Friederici (1983) claimed that even when children do begin producing FWs they do not yet possess the specialized, automatic retrieval mechanism for FWs until about 10 years of age. Thus, "*...younger children are not very sensitive to closed-class items and the structural information given as they listen to a sentence, but rather focus on a sensible representation of meaning… the capacity to automatically process syntactic information independent of semantic context, as adults do, seems to be acquired very late*".

[11] *The Semantic Bootstrapping Hypothesis* is typically not considered a UG-based theory. However, this hypothesis does accept the general concepts and assumptions of UG such as phrase structure and distinct word classes.

3.5. *Behaviorist/Learning Theories*

In contrast to UG-guided theories, behaviorist theories of language learning are based on the notions of associative learning, imitation and reinforcement. Such theories emphasize the environment's (i.e., experience, rather than innate structures) role in providing a model and in shaping children's linguistic behavior through rewards and correction.

The basic assumption in learning-based theories is that the child gradually moves from straightforward mappings between specific words and specific physical referents, to the construction of more abstract syntactic categories and rules, and that children do so by using general cognitive learning mechanisms, which are not specifically related to language. The main reasons this approach cites for the discrepancy between child and adult grammar are cognitive constraints on learning rate, memory capacity limits, and simply the lack of sufficient exposure to exemplars of certain types of words, phrases and sentences.

Specifically regarding FCs, most learning theories posit that FWs are acquired only later in development, after a basic, more 'primitive' lexicon of content words has been assembled. Consequently, for learning theorists such as Tomasello (2000a,b, 2002) - the fact that at early stages children tend to produce only one meaningful word (i.e., a content word) at a time, suggests that children learn language item by item without initially consulting any abstract categories or structures.

Hence, according to Tomasello (2000a,b, 2002), syntactic categories are not psychologically real for young children and so, young children's processing of language is not structure-dependent (i.e., attending to phrasal constructions) but rather relies on specific words and expressions of meaning. Thus, children presumably first operate on the basis on concrete, item-based constructions; and build more abstract linguistic constructions only gradually - on the basis of linguistic experience in which frequency plays a key role.

3.6. *Chapter Summary*

Chapter 3 provided an overview of a range of theories and hypotheses addressing children's acquisition of language, each of which can be tied to one of two basic types, depending on whether it adheres to the principles of UG or not. Moreover, each of these theories holds different predictions regarding the child's acquisition of FCs and the degree of importance which FCs may have during the early stages of language acquisition.

In *Chapter 4*, I review the experimental work which has attempted to discover the timeline in which FCs are acquired; the underlying mechanisms in this process; and how the child's acquisition of FCs interacts and relates to the acquisition of the general (content) lexicon.

Finally, in *Chapter 7* I return to the leading theories and hypotheses in the ongoing debate regarding the acquisition of FCs and contrast them with findings which have been reported in the field, and in particular, with the empirical findings which the current research program has yielded.

CHAPTER 4

EXPERIMENTAL INQUIRIES OF CHILDREN'S REPRESENTATION AND ACQUISITION OF FUNCTIONAL CATEGORIES

Do young children at the early stages of language acquisition[12] consult functional elements in their processing and computation of linguistic input (as adult speakers do)? Do they rely instead on content-carrying items such as nouns and verbs, which convey meaning and reference more directly?

As discussed above, the well-documented fact that young children typically omit FWs in their speech has led to the general claim that FWs are not recognized as distinct units during the early stages of language acquisition and are incorporated in children's computation of linguistic input only later in development (e.g., Bowerman, 1973; Brown, 1973; Grimshaw, 1981; Macnamara, 1982; Pinker, 1982, 1984; Radford, 1990, 1997; Schlesinger, 1971, 1981; Tomasello, 2000a,b, 2002).

Although these researchers differ considerably in their basic conception of first language acquisition, they generally agree that in the initial stages of language acquisition children are 'deaf' to functional elements, and focus on content rather than grammatical elements in processing linguistic input.

It is worth noting at this point that the theoretical views which have denied a central (or any) role for FCs in children's (early) acquisition of language, may in fact provide a good example to some common shortcomings in the field of developmental psycholinguistics. Specifically, researchers' tendency to over-rely on (i) Natural speech data (ii) Children's acquisition of English as a first language; and (iii) Children's productive speech.

[12] That is, from birth to around 3 years of age.

An examination of the empirical results yielded from an array of cross-linguistic, experimentally controlled studies which have tested the validity of these claims, now suggests that young children do not always fail to produce FWs in their language, and are also often sensitive to these elements in perception, already during the very early stages of language acquisition. Thus, the omission of FWs does not necessarily reflect that young children are not aware of these linguistic elements but may rather stem from phonological and motor limitations in speech production[13].

Specifically, researchers have provided comprehensive evidence from several languages (e.g., Dutch, English, French, German) and have used various behavioral methods (e.g., Act-out; Elicited imitation; Preferential-looking; Headturn preference) as well as ERP – to demonstrate that early in the acquisition of language, young children do distinguish between function versus content word categories in language. The next section reviews this literature in detail.

4.1. *Early Production of Functional Categories*

Gerken *et al*. (1990) tested infants of 23-30 months in an experimentally controlled elicited imitation task using sentences containing English or nonsense FWs (e.g., *Pete push<u>es</u> <u>the</u> ball*; *Pete pus<u>ho</u> <u>na</u> ball*). Infants omitted the English FWs significantly more than the nonsense FWs, hence suggesting that they recognized the distinction between the English and nonsense FWs.

It has also been shown that the limitations on the production of FWs are often language-specific. In some languages children do produce certain types of FCs earlier, more frequently, and more consistently than in English (See Lust, 2006, for a comparative, cross-linguistic literature review).

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[13] See *Chapter 7* for further discussion.

For example, Choi and Gopnik (1995) have shown that already during the holophrastic, single-word stage, young Korean children can use verb-ending suffixes in a spontaneous and appropriate manner. Likewise, Demuth (1990) showed early mastery of possessives in Sesotho. Therefore, the omission of functional elements by young learners of English does not seem to reflect a universal phenomenon nor a biological constraint in child language, as some researchers have previously assumed.

In addition, by carrying out a fine-detailed phonetic analysis, Carter & Gerken (2004) have demonstrated that two-year-old children do not completely delete weak syllables that are typical in English FWs, but rather show 'whisper-like' prosodic traces of the omitted syllable. Thus, even in the early production of English, although unstressed FWs are omitted, a close examination of children's speech indicates that they do recognize and attempt to produce these words.

4.2. *Studies Using Discrimination and Comprehension Tasks*

Two seminal studies demonstrated that 'telegraphic-speaking' children were better able to respond to utterances that contained FWs than to utterances from which FWs were omitted (Shipley, Smith, & Gleitman, 1969; Petretic & Tweney, 1977). In other studies, Katz, Baker and McNamara (1974) found that children as young as 17 months considered novel words (e.g., *dax*) as proper or common nouns based on the type of article that preceded them, that is, classified an object addressed as "*a dax*" as a common noun and "*dax*" as a proper noun (see also Gelman & Taylor, 1984). Shady (1996) used the *Headturn Preference Procedure* in a verbal inflection task to measure infants' preference for paragraphs in which real (i.e., English) or nonsense FWs had been switched around or substituted, versus a control paragraph in which English FWs were in their grammatical positions. Infants preferred the paragraphs that used real FWs at 10.5 months and real FWs in the right grammatical order by 16 months.

Similarly, Shady, Jusczyk, and Gerken (1998) found that 10.5-month-old infants listened significantly longer to passages with real FWs than to ones with nonsense words as substitutes for the FWs. The same pattern of response occurred even in a condition in which the nonsense words had similar phonetic properties to real English FWs (whereas in another experiment in which nonsense words were substituted for FWs, no significant headturn preference to these two types of passages occurred). Thus, infants were not merely responding to the occurrence of nonsense words in some of the passages, but had developed some specific expectations for FWs that should occur in English utterances.

Multiple other behavioral studies have now provided further evidence for infants' highly-detailed sensitivity to FWs in the speech stream in several languages such as English, German, Dutch and French (e.g., Halle & de Boysson-Bardies, 1994; Halle, Durand, & de Boysson-Bardies, submitted; Höhle & Weissenborn, 2003; Johnson, 2004, 2005; Seidl & Johnson, 2006; Shi, Cutler, & Werker, 2003; Shi, Werker, & Cutler, 2006; Shi, Cutler, Werker, & Cruickshank, 2006; Shi & Gauthier, 2005; Zangl & Fernald, 2003). For example, Zangl and Fernald (2003), using a version of the IPLP methodology which attempts to measure online processing efficiency, found that 18 month olds' sentence processing was hindered by sentences using nonsense words (e.g., "*Look at loo shoe*") as compared to sentences with grammatical determiners (e.g., "*Look at the shoe*").

Two recent studies using infant preference methods reveal additional aspects of early sensitivity to FCs. Santelmann and Jusczyk (1998) used the *Headturn Preference Procedure* to test whether 18-month-old infants are not only aware of the relationships between function and content words in general, but perhaps also more specifically between *free* and *bound* grammatical morphemes which co-occur in English phrases. Infants showed a significant preference in listening time to passages in which the auxiliary '*is*' was followed by a main verb ending with the functional suffix '*-ing*' (e.g., "*everybody is baking bread*") hence forming a grammatical sentence in English, rather than to sentences which contained an ungrammatical combination of the modal auxiliary '*can*' and a main verb ending with '*-ing*' (e.g., "*everybody can baking bread*"). Based on these findings, Santelmann and Jusczyk (1998) claimed that the infants were aware of the fact that the functional morphemes '*is*' and '*-ing*' – although not directly adjacent in sentences - are often structurally related to each other in English phrases and sentences.

Golinkoff, Hirsh-Pasek, and Schweisguth (2001) tested 18- to 21-month-old infants' sensitivity to the suffix '*-ing*' attached to a verb stem. In a preferential-looking task, the infants were presented with three types of linguistic stimuli: a grammatical form (e.g., '*dancing*'), an ungrammatical form (e.g., '*dancely*') and a nonsense form (e.g., '*dancelu*'). The type of suffix was a between-subject variable. Three groups of infants were each assigned a single type of bound morpheme ('*-ing*', '*-ly*', '*-lu*'), with four test trials using different verbs (e.g., *dance*, *drink*). Visually, two dynamic actions were presented simultaneously, of which only one action matched the verb stem (e.g., hearing a sentence in which '*dancelu*' is presented, and then watching a figure dancing on one screen and waiving on the other).

Golinkoff *et al*.'s (2001) findings demonstrated that infants who were presented with the grammatical form had a significantly longer average looking time to the matching screen than to the non-matching screen. In contrast, children tested on the ungrammatical form looked longer to the matching screen only in the last three verbs. Thus, the first appearance of the unexpected morpheme '*-ly*' seemed to cause a distraction for the infants. Moreover, infants failed to look longer to the matching screen in the nonsense condition (with girls looking longer to the non-matching screen).

Thus, the three groups of infants demonstrated different looking patterns, with the grammatical bound morpheme '-*ing*' attached to the verb stem being the best predictor of infants looking longer at the matching screen. In sum, the findings reported by Santelmann and Jusczyk (1998) and Golinkoff *et al*.'s (2001) demonstrate that 18-month-old infants are not only sensitive to co-occurrence patterns of (English) function and content words; but can also detect the (non-adjacent) distributional relations in spoken English between free and bound functional elements (e.g., '*is*' and '-*ing*') and between content words and their complementary bound morphemes (e.g., '*dancing*' vs. '*dancely*').

Lastly, Shi, Werker and Morgan (1999) examined whether even much younger infants, in fact, 1-to-3-day-old newborns - would be able to distinguish function versus content words in English. In a *Habituation-By-Sucking* experimental design, the newborns were presented with lists of content words and FWs prepared from natural maternal speech. To examine whether such ability, if present, is universal - newborns whose mothers spoke only English were compared with newborns whose mothers primarily spoke other languages. After being habituated to one list of tokens (either '*Grammatical*' or '*Lexical*'), the newborns were tested on novel lists of tokens: Newborns in the experimental group were tested on a list of tokens from the opposite category, while newborns in a control group heard novel tokens but from the same category.

Shi *et al*.'s (1999) results showed that both directions of change within the experimental group but not within the control group had a significant recovery from habituation. Prenatal exposure to English had no effect – in both groups there was a significant recovery only in the experimental group. Thus, Shi *et al*. (1999) concluded that 1- to 3-day-old newborns categorically discriminated these sets of words.

The findings reviewed above lead to three conclusions regarding the acquisition of FCs. First, young children can detect FWs and use the distinct characteristics of these grammatical elements to segment the speech stream into words and phrases. Second, children are able to discriminate between function and content words (as well as nonsense words) already at an early age. Lastly, the omission of FWs in early speech does not result from a deficit in infants' competence to detect and process FWs[14]. Furthermore, the work presented here generally demonstrates how the young child's productive abilities are dramatically different from their competence in language comprehension. Specifically in regards to FCs, these findings correspond to the idea of dissociation between the child's perception and processing of FWs, versus their (limited) ability to produce specific FWs in their language.

4.2.1. *Underlying Mechanisms in Early Segmentation of FWs*

What mechanisms could possibly explain such early linguistic skills which infants possess? Which linguistic cues could facilitate this discriminative process? It has been commonly assumed that infants detect FWs in the linguistic input based on an array of phonological, prosodic and distributional (i.e., location and frequency) characteristics, which FWs typically share. For example, FWs are highly frequent in language; typically composed of a small set of phonemes; characterized by a simple (e.g., monosyllabic) lexical structure that is often unstressed; and typically appear in peripheral phrase positions (e.g., the determiner '*the*' always occurs at the beginning of NPs) in which words have been shown to be segmented faster and more reliably than utterance-medial words (Aslin, 1999; Demuth, 1992, 1994; Gerken *et al*., 1990; Maratsos, 1982; Morgan, 1986; Seidl & Johnson, 2006; Shi *et al.*, 1998).

[14] See *Chapter 7* for several alternative proposals for why FWs are often omitted in early speech.

4.3. *Early Sensitivity to the Grammatical Role of Function Words*

While the studies reviewed above demonstrate infants' early detection of FWs in speech, they do not address the question of how early this discriminative ability also serves for detecting the *grammatical* function of specific FWs (e.g., '*the*' and '*if*' not only sound differently - but carry different grammatical functions in English). Thus, in another line of research, studies were designed to explore whether young children can distinguish between specific FWs that carry different syntactic roles (e.g., *Determiners* vs. *Conjunctions*). In particular, it has been explored whether such sensitivity would have an active role in –

(i) Guiding young children's processing and syntactic judgment of sentences;

(ii) Aiding the syntactic categorization of novel nouns and verbs (e.g., inferring that a novel word is a noun based on the fact that it is preceded by a determiner);

(iii) Determining word reference.

Gerken and McIntosh (1993) first explored these critical issues in a study with 21- to 28-month-olds, using a picture-identification task that required children to point to a picture in response to one of four sentence types. In each sentence type, a concrete noun (e.g., *bird*, *car*) referring to one out of four pictures was preceded by (i) an English determiner that was grammatical in that context (e.g., "*show me <u>the</u> bird*"); (ii) an English auxiliary that was ungrammatical in that context (e.g., "*find me <u>was</u> bird*"); (iii) a nonsense-syllable, serving as an unfamiliar FW (e.g., "*point <u>gub</u> bird for me*"); or (iv) no FW ('*null*'; e.g., "*show me bird*"). If children would rely only on the target noun for performing the task, no difference in their response to the grammatical or ungrammatical sentences should occur. However, children pointed to the target picture significantly more following sentences in which the grammatical article ('*the*') occurred rather than following sentences in which the ungrammatical auxiliary (‘*was*’) or a nonsense-syllable (‘*gub*’) preceded the target word. Based on these results, Gerken and McIntosh (1993) argued that FWs are not only detected by the child, but that they must play a significant role for young children’s comprehension of language, specifically with regard to their early computation of word reference.

Höhle *et al*. (2004) tested 12- to 16-month-old German infants in a headturn preference task on their ability to determine the syntactic category of a novel word depending on the type of FWs which preceded it (e.g., using the occurrence of a determiner for labeling an adjacent novel word as a noun). In one of the conditions, infants were first familiarized with two strings of a German determiner followed by novel (nonsense) words: *ein glamm*, *ein pronk* (*a glamm, a pronk*). After familiarization, infants were tested on four six-sentence passages wherein the novel words were used in contexts which either clearly marked a noun phrase such as *das Glamm* (*the glamm*), *dieses Glamm* (*this glamm*), *den armen Pronk* (*the poor pronk*), das wunderbare Glamm (*the wonderful glamm)* - or where the novel word appeared in a verb context such as *Der Junge glamm* (*the boy glammed*), *Manchmal pronk der Förster* (*Sometimes pronk(ed) the ranger*).

Importantly, none of the FWs presented during familiarization (i.e., ‘*ein*’) were used in the test passages. Thus, infants had to rely on familiarity with the functional category of *Determiners* to categorize the novel word as a noun rather than simply memorizing a specific function-content word combination. Höhle *et al*. hypothesized that if infants rely on the type of FWs used in the familiarization stage to categorize the novel word, they should respond differently to the passages presented during the test phase as a function of whether the novel word occurred in a linguistic context that matched the context used during familiarization.

Infants of 14- to 16-months (but not of 12- to 13-months) had significantly longer average listening times for the verb passages than for the noun passages. Based on these results, Höhle *et al*. claimed that infants relied on the fact that a determiner preceded a novel word to categorize the novel word as a noun, thus demonstrating syntactic knowledge of German. These findings indicate that already at 14 months children may be able to extend the category information related to a specific syntactic context in which a novel word appears into other instances of the same syntactic class (see also Peterson-Hicks, 2006, for a similar design with 15-month-old English-learning infants).

Lastly, Bernal *et al*. (in press) report a preferential-looking study in which 23-month-old infants demonstrated early sensitivity to the grammatical role of French FWs and appeared to consult certain FWs for the syntactic categorization of words and phrases. Hence, infants' looking responses indicated that they differentially categorized an unfamiliar word either as a noun or as a verb, based the specific FW that preceded it. Thus, infants would look preferably towards a scene in which a particular action was highlighted if the FW indicated that the target (novel) word was a verb, but would focus on a specific object when the sentence implied that the novel word was a noun.

4.4. *Early Processing of Functional Categories - Neurolinguistic Findings*

One advantage of the ERP method when testing children is that since the brain responses are time-locked to the linguistic stimuli, this measure seems more accurate in comparing children's response to ungrammaticalities rather than the pointing, listening and looking responses used in the behavioral studies mentioned above. However, only a few studies to date have applied brain-imaging techniques in general - and ERP in particular - to investigate early processing of FCs in young children.

Shafer *et al.* (1998) used the *tone-probe* variation of the ERP method to identify when infants become sensitive to FWs in the speech stream. To test infants' attention to the prosodic and segmental characteristics of English FWs, 10- and 11-month-old infants heard both a modified and an unmodified version of a story - one with nonsense FWs, the other with English FWs. The event-related potentials were time-locked to tones that were superimposed on the two story versions. The authors hypothesized that if infants would attend more to the verbal language than to the tones, their response to the tones would be smaller.

For each ERP, four reliable peaks were identified: negative peaks between 80-150 ms (N1) and between 200-400 ms (N2), and positive peaks between 160-250 ms (P2), and between 280-500 ms (P3). Amplitude scores for each peak were obtained by computing peak-to-trough and trough-to-peak voltages (in microvolts) for N1-P2, P2-N2, and N2-P3 for each ERP. The 11-month-old infants (but not the 10-month-olds) showed a significant difference in the peak-to-peak difference between P2-N2 (primarily at the center (Cz) electrode site) between the modified and the unmodified conditions, with infants allocating more attentional resources for the processing of the modified rather than the unmodified version of the story. Shafer *et al*. (1998) concluded that the age in which infants begin detecting specific FWs in language is around 11 months.

In an ongoing study, Christophe *et al*. (2006) have been running an ERP task with both adult participants and 2-year-old infants. The infants' ERP responses indicated that they detected ungrammatical sentences in which French FWs were improperly used. Specifically, Christophe *et al*. made use of the homophony in French between the definite article '*la*' and the object clitic '*la*'. For example, '*la mange*' (*the eat*) is ungrammatical, but *'je la mange*' (*I it eat*) is grammatical. In contrast, attaching the same FWs to a noun (e.g., '*fraise*' - *strawberry*) yields a reverse pattern (i.e., '*la* *fraise*' is grammatical, while '*je la fraise*' is ungrammatical). These results were obtained although the transitional probabilities between adjacent words were held constant, hence suggesting infants' early syntactic sensitivity and categorization of different FCs in French (i.e., in contrast to merely noticing the distributional co-occurrence patterns of these FWs).

In contrast to these findings, several researchers have claimed that during the first stages of language acquisition, the typical brain responses associated with syntactic processing (such as the ELAN response) are missing. According to this view, syntactic processes develop later than processes involved in semantic and pragmatic processing. Specifically regarding the acquisition of FCs, it has been hypothesized that children's processing of FWs is not specialized but rather elicits ERP waveforms that are typically associated with the processing of content words in adults.

For example, Neville, Mills and colleagues (Mills, Coffey-Corina & Neville, 1997; Neville, 1995; Neville *et al*., 1992; Neville & Mills, 1997; St. George & Mills, 2001) have argued for a gradual development of the distinction between function versus content words. These researchers report a series of studies in which children between the ages of 20- to 42 months were tested on word lists which presented function versus content words.

No ERP word-class differences were found at 20 months of age, despite the fact that all children understood and produced all of the words in a comprehension and a production pretest[15]. According to these authors, differences developed only gradually and became apparent by 30 and 40 months of age. Specifically, for the 28-30 month-olds, a left hemisphere N200 was larger in response to content words at frontal, temporal, parietal and occipital sites over both hemispheres, whereas over the

[15] However, it is important to note that the authors chose an unusual set of exemplars as closed-class words (e.g., *up*, *down*, *out*, *off, more*) rather than more typical English FWs.

right hemisphere, N450 and N500 were larger in response to FWs[16]. By 3 years of age, N200 and N450 showed a left hemisphere asymmetry to FWs and a symmetrical pattern in response to content words, similar to older children and adults.

Based on these studies, Neville, Mills and their colleagues argue that unlike adults, infants initially dedicate similar brain systems and areas to process both word classes, and these systems only gradually (with experience) become specialized for distinguishing and processing each of these word classes.

4.5. *Chapter Summary*

Behavioral Findings. Ample cross-linguistic research on young children's acquisition of FCs has demonstrated over the last few decades that already during children's first two years of life, functional elements such as determiners, conjunctions, auxiliaries and bound morphemes are in fact detected and segmented from continuous speech. Moreover, FWs are categorically distinguished from content words as well as from nonsense words[17] (Gerken, *et al*., 1990; Halle, *et al*., submitted; Höhle & Weissenborn, 2003; Johnson, 2004, 2005; Katz, *et al*., 1974; Petretic & Tweney, 1977; Seidl & Johnson, 2006; Shady, 1996; Shafer, *et al*., 1998; Shi, *et al*., 2003; Shi, *et al*., 2006a,b; Shi & Gauthier, 2005; Shipley *et al*., 1969; Zangl & Fernald, 2003). At 18 months of age, infants have also been shown to detect co-occurrence patterns between free and bound English FWs (e.g., *is dancing*, Santelmann & Jusczyk, 1998); and notice specific relations between English verb stems and their complementary bound morphemes (Golinkoff, *et al*., 2001).

[16] Similar ERP responses were also observed in a group of 20-month-olds who were classified as advanced speakers.
[17] Young children not only distinguish function versus nonsense words, but also seem to treat the two types of words differently, that is, FWs are preferred over the nonsense words.

Importantly, this early sensitivity to FWs in child language seems to be in place already at a developmental stage during which children's productive language is not fully developed. That is, in 'telegraphic-speaking' children (i.e., between around 6- and 30 months of age); 'pre-verbal' infants (i.e., 0-6 months); and even in newborns (see Shi *et al.*, 1999) – all of which typically do not produce full sentences or use FWs in their productive speech.

In a subsequent line of research, it has been questioned whether in addition to the ability, which infants demonstrate already during the first year of life, to detect FWs in the linguistic input (i.e., segmentation of FWs from the continuous speech stream); infants (in their second year of life) would recognize that certain FWs are associated with different FCs. That is, would infants demonstrate awareness to the different roles that certain types of FCs/FWs (e.g., determiners versus verb inflections) have in the construction of sentences?

This line of study has yielded some surprising results demonstrating that already during children's second year of life - that is, at a developmental stage in which FWs do not typically appear in a consistent or a correct manner in children's productive speech (in certain languages such as English) – young children seem to incorporate FWs in their syntactic computation of sentences.

Specifically, children have been shown to be using FWs to syntactically categorize words and phrases in their linguistic input. This early syntactic sensitivity has also been shown to guide and facilitate young children's ability to determine noun reference and sentence meaning (e.g., Bernal, *et al*., in press; Gerken & McIntosh, 1993; Höhle, *et al*., 2004; Kedar, *et al.*, 2006; Peterson-Hicks, 2006; Shady, 1996; Shady & Gerken, 1999).

Neuroscience Findings. The picture emerging from neurolinguistic studies on children's early representation and processing of FCs is not as clear as in the case of the behavioral literature. Specifically, while some of the neuroscience findings mentioned above (Christophe *et al*., 2006; Shafer *et al*., 1998) converge with the behavioral literature, results from other studies (e.g., Mills, *et al*., 1997; Neville, 1995; Neville *et al*., 1992; Neville & Mills, 1997; St. George & Mills, 2001) do not correlate with the behavioral findings. This incongruence obviously calls for further research - an issue to which I return in *Chapter 7*.

4.5.1. *The Current Research Program*

As demonstrated above, studies on infants' developing sensitivity to the grammatical role of FCs in language has generally focused on the *Determiner* systems in English (Gerken & McIntosh, 1993; Kedar, *et al.*, 2006; Peterson-Hicks, 2006; Shady, 1996), French (Bernal *et al*., in press) and German (Höhle, *et al*., 2004) - most likely because determiners are highly frequent and are also crucial for the organization of sentences in these languages. These studies have shown that already by two years of life, children are sensitive to certain syntactic properties of FCs. In establishing the current research program, which is described in detail in *Chapters 5* and *6*, I attempted to replicate and extend the previous findings on this matter by using a different method – the *Intermodal Preferential Looking Paradigm*. Furthermore, the current studies were designed in order to begin to explore some of the broader and unresolved issues in the study of FCs in language acquisition. Most importantly, I have focused on the scientific challenge of not only pinpointing the developmental timeline in which FCs are incorporated in infants' processing of language (or the stages in which this ability becomes *apparent* in the child); but also the challenge of discovering the principle mechanisms and constraints which guide and enable this process.

CHAPTER 5

RESEARCH PROGRAM: RATIONALE AND DESIGN

The current research program aims at validating as well as extending previous studies which have been exploring when and how children begin distinguishing and processing FWs based on their unique grammatical role in sentences (e.g., Bernal *et al*., in press; Christophe *et al*., 2006; Gerken & McIntosh, 1993; Höhle *et al*., 2004; Kedar *et al*., 2006; Peterson-Hicks, 2006; Shady, 1996; Shady & Gerken, 1999).

5.1. *Linking the Psycholinguistic Literature on FCs to Current Syntactic Theory*

In general, two basic (complementary) rationales have motivated previous studies as well as the current research program. First, a major challenge in the field of developmental psycholinguistics has been linking the empirical study of language acquisition to the proposed syntactic model in current linguistic theory.

As discussed earlier, according to this model, each of the fundamental FCs - *Determiners*, *Complementizers* and *Verb Inflections* - serves as a head for the basic phrase constituents of a sentence. Thus, FCs are assumed to carry a critical role in establishing the structural skeleton of sentences and in enabling some essential syntactic operations (e.g., movement, agreement) for comprehending and producing language (e.g., Abney, 1987; Bowers, 1987; Chomsky, 1995, 2000; Hellan, 1986; Lust, 2006; Reuland, 1986).

As reviewed above in *Chapter 2*, this view has been supported by experimental studies in which adult subjects experienced difficulty in mastering an artificial linguistic code if functional elements were omitted; or if the ratio between function and content words was different from the ratio found in natural languages, that is, FWs being much more frequent than content words (e.g., Cutler, 1993; Frigo & McDonald, 1998; Gomez & Gerken, 2000; Gomez & LaKusta, 2004; Green, 1979; Valian & Coulson, 1988).

In the study of child language acquisition, the critical question is therefore whether FCs would also have such a fundamental role in the computation and representation of language; or alternatively, whether the adult state of syntactic organization and processing in regards to FCs is reached only later in development.

5.2. *Function Words as Linguistic Cues*

A second rationale for exploring whether FWs may be grammatically functional early in the acquisition of language is the (bottom-up driven) hypothesis that by attending to the recurring phonological, prosodic and distributional characteristics which FWs typically share - young children could derive some useful information for:

(i) Segmenting the continuous speech stream into a set of distinct constituents.

(ii) Discovering the syntactic class of words and phrases.

According to this view, young children could be using a comprehensive strategy in sentence processing, one which incorporates not only the meaning-carrying units (i.e., content words) but also the functional elements in language (e.g., Christophe, Guasti, Nespor, Dupoux, & van Ooyen, 1997; Clark & Clark, 1977; Gerken & McIntosh, 1993; Gerken *et al*., 1990; Golinkoff *et al*., 2001; Morgan, 1986; Valian & Coulson, 1988).

5.3. *Goals*

This research program attempted to replicate Gerken and McIntosh's (1993) essential findings, using however a different paradigm - *The Intermodal Preferential Looking Paradigm* (IPLP; Golinkoff, Hirsh-Pasek, Cauley & Gordon, 1987; Hirsh-Pasek & Golinkoff, 1996).

One major goal was to discover whether the early incorporation of English determiners in infants' sentence processing - which has been demonstrated in Gerken and McIntosh's (1993) study with 2-year-olds and which included a visual-referential effect (i.e., infants' determination of noun reference and the location of a visual target) - would also be traceable by using the IPLP.

In addition, the current work explored whether such early syntactic sensitivity to the grammatical role of FWs (in particular, *Determiners*) could be shown to be present even at earlier stages in the acquisition of language, that is, already during stages in which infants hardly produce any FWs (or content words). Specifically, it was investigated how infants of 12 and 18 months would perform on the task in comparison to the 2-year-olds tested in this research program as well as in Gerken and McIntosh's (1993) study.

Thus, this research programs attempted to trace the developmental timeline during which infants' sensitivity to the syntactic properties of different English FWs becomes apparent. Lastly and perhaps most importantly, the present work explores the foundations and basic mechanisms that may account for infants' accessibility to FCs in language already during the very early stages of language acquisition.

5.4. *Design & Hypotheses*

As in Gerken and McIntosh's (1993) study, the current design with 12, 18 and 24-month-old infants contrasted a well-formed determiner ('*the*') with –

(i) A non-well-formed one ('*el*')

(ii) An omitted-FW condition ('*null*').

Since '*el*' is a well-formed FW in Spanish, it was verified that none of the infants knew Spanish. Thus, it could be assumed that '*el*' was equivalent to a nonsense word for the English-acquiring infants who were tested in the current studies. If infants respond differently to the ungrammatical sentences in comparison to the grammatical sentence using '*the*', this would provide evidence that they attend to FWs in continuous speech, distinguish a familiar FW such as '*the*' from an unfamiliar one (i.e., '*el*'), and notice the omission of a single FW ('*the*') from a sentence.

'THE' vs. 'AND'. In addition, a third condition contrasted a grammatical versus an ungrammatical type of sentence by manipulating a single English FW ('*the*', '*and*'). Both '*the*' and '*and*' are highly frequent in English but carry different grammatical roles and belong to different kinds of FCs (i.e., DP versus CP, respectively). For this reason, the '*The*' versus '*And*' contrast was most critical since only the determiner '*the*' was grammatically correct in the specific sentence structure tested. If infants distinguish FWs that are mismatched with their syntactic phrases, this may indicate that the functional category (i.e., *Determiners*) is syntactically linked to its complement and therefore grammatically functional during early stages in the acquisition of language.

Furthermore, since Gerken and McIntosh's (1993) study contrasted the determiner '*the*' with the auxiliary verb '*was*', the current design generalized this condition with a new pair of FWs ('*the*' versus '*and*'). This generalization is important because the FWs '*the*', '*was*' and '*and*' each serve as a functional head for different phrase types: DP, IP and CP, respectively.

In sum, the current design was based on the assumption that if infants would recognize the FW-manipulation, and so discriminate the FW-variation, they would perform differently on the grammatical and ungrammatical conditions in the task. Specifically, following the grammatical sentences, infants were predicted to orient significantly faster towards the target image as opposed to the ungrammatical conditions; identify the target image significantly more on their first look; and overall look longer towards the target image while both images are presented.

5.4.1. *Using the Intermodal Preferential Looking Paradigm*

As mentioned above, the experimental work that is described in *Chapter 6* also differed from Gerken and McIntosh's (1993) study by using the *Intermodal Preferential Looking Paradigm* (IPLP). This method has been proven useful in evaluating young children's looking behavior as an indicator of their computation of linguistic input. Specifically, several advantages seem plausible in using the IPLP for assessing infants' use of FWs in sentence processing and for determining reference.

First, infants do not interact with the experimenter, hence eliminating the possibility of the experimenter biasing infants' responses. Second, the preferential looking procedure allows infants to visually choose between two images - an accessible response, both cognitively and motorically, which may be more easily available to children than choosing a target picture by producing a point. Third, the videotaped session can be coded offline frame-by-frame, improving coding accuracy as well as providing greater measurement precision. Fourth, the IPLP allows testing younger children than those tested in a task which involves controlled pointing.

Finally, recording each infant's time and direction of look enabled the use of multiple measures of how infants were responding to the different types of sentences, thus creating a basis for converging evidence as well as possibly discovering new information regarding infants' representation and processing of FCs. Specifically, four dependant variables were calculated from the recorded testing sessions:

1. *First Look*: All test trials were categorized as either YES or NO based on whether infants correctly looked towards the target image on their first look (i.e., regardless of how long it took them to orient to target).

2. *Latency*: Duration of time from the presentation of the two images to infants' initial fixation to the target image.

3. *Immediate Latency*: A more constrained analysis of latency, taking into account only the cases (across all four FW conditions) in which infants' first look was directed to the target image.

4. *Difference in Proportion of Looking Time* to target - from baseline trials to test trials. The *Proportion of Looking Time* (PLT) measure was calculated by dividing an infant's looking time to target by their total looking to the distractor and target during a trial. A difference score was calculated by subtracting infants' PLT in the baseline trial from their PLT in the test trial.

CHAPTER 6

EXPERIMENTAL STUDIES

This chapter reviews three experiments in which infants of 12, 18, and 24 months were tested in a preferential-looking task on their ability to recognize ungrammaticalities in English sentences which were caused by either substituting a well-formed English FW (‘*the*’) with another word or by omitting it.

6.1. *Experiment 1*

Experiment 1 was designed in order to extend previous findings by exploring whether young language learners’ (18- and 24-month-olds) would be able to not only generally recognize certain FWs as part of their English lexicon - but also to consult FWs in the grammatical processing of a sentence. Specifically, infants were tested on their ability to use the English determiner ‘*the*’ to establish a referent for a NP (*Noun Phrase*).

Experiment 1 had four main goals:

1. Replicate Gerken and McIntosh’s (1993) findings with 24-month-old infants, using however a preferential-looking task.
2. Examine whether 24-month-old infants would be able to distinguish the English determiner ‘*the*’ from the English conjunction ‘*and*’ – both appearing in a sentence - thus testing the infants’ ability to distinguish between a new pair of English FWs which carry different grammatical roles (that is, in addition to the ‘*the*’ versus ‘*was*’ contrast which was tested by Gerken and McIntosh, 1993).

3. Test whether the use of a different method (i.e., preferential-looking) could possibly point to additional findings (i.e., differences) among the four test conditions (i.e., *Grammatical FW*; *Ungrammatical FW*; *Nonsense FW*; *No FW*). In particular, *Experiment 1* explored whether a significant difference in the way infants process the grammatical sentences using '*the*', in contrast to their processing of the omitted-FW condition ('*null*'), would be evident. This contrast was not statistically significant in Gerken and McIntosh's (1993) study.
4. Test infants of 18 months on the same task to explore whether these younger infants would show similar response patterns to those shown by the infants from the 24-month-old age group in *Experiment 1* as well as in Gerken and McIntosh's (1993) study. In this way it was hoped to investigate the developmental origins of children's sensitivities to FCs.

6.1.1. *Method*

Participants. Sixteen 24-month-olds (15 reported by parents as Caucasian, 1 reported as '*Other*'; 9 females, 7 males) and sixteen 18-month-olds (14 Caucasian, 1 Hispanic, 1 '*Other*'; 7 females, 9 males) participated. Infants in the older age group had a mean age of 24;01 (*SD* = 13.55 days) and those in the younger age group had a mean age of 17;25 (*SD* = 21.1 days).

All infants were full-term, healthy, had no history of auditory or visual impairment, and did not hear any language on a regular basis other than English. Infants were recruited through a letter given to parents at the time of their child's birth. All infants, regardless of their performance on the task, received a small toy in appreciation of their participation.

Seven additional 24-month-olds (four females, three males) were not included in the final sample due to fussiness or non-attentiveness throughout most or all of the test session (n = 4), bilingualism (n = 2), or failure to complete the test session (n = 1). Six additional 18-month-olds (three females, three males) were not included in the final sample due to fussiness or non-attentiveness (n = 4), or due to a side preference issue (n = 2).

Stimuli. The visual stimuli were 16 color images of objects and animals: a ball, bed, bird, book, brush, car, cat, cup, dog, duck, hat, phone, plane, shoe, spoon, and a truck (See the *Appendix*). The lexical norms of the *MacArthur-Bates Communicative Development Inventory: Words and Gestures* (MCDI; Dale & Fenson, 1996) indicated that by 16 months, most English-learning infants are familiar with the labels for these objects.

The images were paired according to their reported MCDI familiarity proportion among 16-month-old infants, so that each pair of images had approximately the same familiarity proportion (see *Table 1*). In addition, animal characters were matched only with other animal characters to control for a possible preference for animate over inanimate objects. Images within each pair had the same background, and were approximately the same size.

Table 1
Experiments 1 & 2: Mean percent of infant familiarity with the test nouns at 16 months of age according to the *Macarthur-Bates Communicative Development Inventory*; and the estimated mean percent of infant familiarity with these nouns at 24, 18 and 12 months, according to the parental reports which were collected.

		MCDI	**Parental Report**		
Pair	**Nouns**	**16 Months**	**24 Months**	**18 Months**	**12 Months**
1	Phone	83.3	100	93.7	12.5
	Cup	86.1	81.2	93.7	12.5
2	Hat	61.1	93.75	93.7	25
	Bed	68.1	87.5	93.7	25
3	Plane	66.7	87.5	50	0
	Truck	66.7	93.7	62.5	12.5
4	Car	93.1	100	75	12.5
	Shoe	93.1	100	100	25
5	Ball	93.1	100	100	56.25
	Book	90.3	100	100	43.75
6	Bird	79.2	100	87.5	6.25
	Dog	87.5	100	87.5	56.25
7	Brush	72.2	87.5	50	0
	Spoon	75	100	81.2	18.75
8	Duck	79.2	93.7	87.5	18.75
	Cat	76.4	100	81.2	50

The auditory stimuli were a set of English sentences produced by a female native-English speaker in infant-directed-speech. The sentences were recorded with a Canon digital camcorder and then transferred to a G4 Macintosh computer for editing. Three sentences were recorded in order to be used as attention-getting utterances in the baseline trials (i.e., prior to the test trials): (i) "*Look! Look at these!*"; (ii) "*Look! Look at that!*"; and (iii) "*Wow!*".

In addition, another set of sentences were recorded in order to be used in the test trials. These sentences were carefully prepared and edited in several stages which were designed in order to create a set of sentences in English that would be distinguished only by their grammatical structure, rather than by their phonological or prosodic characteristics. First, 64 sentences with all possible combinations of Function Word ($N = 4$) and Noun ($N = 16$) were recorded (e.g., *Can you see the ball?*; *Can you see el ball?*; *Can you see and car?*; *Can you see book?*).

Next, the best exemplar in terms of vividness, clarity, and inflection of the opening sequence '*can you see…*' was chosen and spliced in as a prototype for all of the 64 edited sentences that were eventually used in the test trials. Similarly, for each of the four FW types, a single exemplar was chosen for all 16 sentences in which it appeared (e.g., 16 combinations of '*the*' followed by a noun). Finally, the clearest exemplar of each noun was spliced in as a prototype in the four sentences it appeared in (e.g., for '*ball*' - *Can you see the ball?; Can you see and ball? Can you see el ball?; Can you see _ ball?*).

Thus, 64 edited test sentences were used in the final set of stimuli. Each of these edited test sentences lasted 2 seconds. In the '*null*' sentences, in which the FW was omitted, there was a very brief gap between the verb '*see*' and the following noun in order to keep the sentence at the 2 seconds timeframe.

Finally, two adult native English speakers were presented with each of the 64 edited sentences and verified that each sentence had normal intonation for a typical interrogative sentence in English.

Apparatus. Adjacent experimental and control rooms were used. In the experimental room, three 20-inch color TV monitors (one in the center, two on the sides) were placed on a table approximately 76 cm from the floor. Infants were seated on their parent's lap approximately 127 cm from the monitors. Low lighting and a black wooden frame surrounding the monitors were used to focus infants' attention on the monitors. A 6.5 cm opening in the frame enabled a camcorder lens to be focused on the infant's face.

Control Room. The experimental room camcorder was linked to a TV monitor in the control room, thus allowing the experimenter to observe the infant during the test session. A VCR which was linked to this monitor enabled videotaping the infants during test sessions. This allowed offline coding of each infant's looking behavior throughout the test session.

The *Habit X* experimental computer program (see Cohen, Atkinson, & Chaput, 2004) was used for controlling the order and the timing of the images' presentation throughout the test session.

Procedure. All parents were given a general description of the preferential-looking procedure and parental consent was obtained.

Next, parents were asked to estimate their infant's familiarity with each of the 16 nouns which were used in the study by marking "*Yes*", "*No*" or "*Not Sure*" next to the noun. Only "Yes" responses given by the parents were counted as indicating infant familiarity with the test nouns.

In addition, infants' level of productive language was assessed based on each infant's *Mean Length of Utterance* (MLU; see Brown, 1973), as recorded in their spontaneous speech produced during the test sessions (for the 24-month-olds), as well as during an introductory play session with the experimenter prior to the test session (with the 18-month-olds).

In the experimental room, the infants were seated on their parent's lap so that their head was facing the three monitors directly. Before the experimenter left the room, parents were carefully instructed to remain neutral and to avoid pointing or talking to their infant during the entire test session.

The infants were randomly assigned to view one of eight lists of sentences, with two infants in each age group (18- and 24-month-olds) receiving each list. As shown in *Table 2* below, each list of test sentences was composed of eight sentences, with two sentences for each kind of FW (e.g., *el book*; *el ball*; *the car*; *the bird*; and so on). The order in which the four sentence types appeared (i.e., *Grammatical FW – 'the'; Ungrammatical FW – 'and'; Nonsense FW – 'el'; Null – no FW*) was quasi-randomized across lists.

Table 2
Sentence lists

Trial	*Target*	*Side of Target*	*List A1 Can you see*	*List A2 Can you see*	*List A3 Can you see*	*List A4 Can you see*
1	**PHONE**	***Left***	*the* ***phone?***	*and* ***phone?***	*_* ***phone?***	*el* ***phone?***
2	**BED**	***Right***	*el* ***bed?***	*the* ***bed?***	*and* ***bed?***	*_* ***bed?***
3	**PLANE**	***Left***	*el* ***plane?***	*the* ***plane?***	*_* ***plane?***	*and* ***plane?***
4	**CAR**	***Left***	*and* ***car?***	*el* ***car?***	*the* ***car?***	*_* ***car?***
5	**BALL**	***Right***	*_* ***ball?***	*and* ***ball?***	*the* ***ball?***	*el* ***ball?***
6	**BIRD**	***Left***	*_****bird?***	*el* ***bird?***	*and* ***bird?***	*the* ***bird?***
7	**BRUSH**	***Right***	*the* ***brush?***	*_* ***brush?***	*el* ***brush?***	*and* ***brush?***
8	**DUCK**	***Right***	*and* ***duck?***	*_****duck?***	*el* ***duck?***	*the* ***duck?***

Trial	*Target*	*Side of Target*	*List B1 Can you see*	*List B2 Can you see*	*List B3 Can you see*	*List B4 Can you see*
1	**CUP**	***Left***	*the* ***cup?***	*and* ***cup?***	*_* ***cup?***	*el* ***cup?***
2	**HAT**	***Right***	*el* ***hat?***	*the* ***hat?***	*and* ***hat?***	*_* ***hat?***
3	**TRUCK**	***Left***	*el* ***truck?***	*the* ***truck?***	*_* ***truck?***	*and* ***truck?***
4	**SHOE**	***Left***	*and* ***shoe?***	*el* ***shoe?***	*the* ***shoe?***	*_* ***shoe?***
5	**BOOK**	***Right***	*_* ***book?***	*and* ***book?***	*the* ***book?***	*el* ***book?***
6	**DOG**	***Left***	*_* ***dog?***	*el* ***dog?***	*and* ***dog?***	*the* ***dog?***
7	**SPOON**	***Right***	*the* ***spoon?***	*_* ***spoon?***	*el* ***spoon?***	*and* ***spoon?***
8	**CAT**	***Right***	*and* ***cat?***	*_* ***cat?***	*el* ***cat?***	*the* ***cat?***

Note: Sentence lists in *Experiment 3* included only the sentences with *ball*, *book*, *car*, *cat*, *cup*, *dog*, *phone*, and *shoe* - 32 sentences in total.

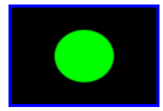
Each infant was given a total of 16 trials (8 Baseline trials; 8 Test trials). As *Table 3* below demonstrates, during a baseline trial, infants viewed a pair of images for 6 seconds after hearing the recorded voice encourage their looking to the images (i.e., using either "*Look! Look at these!*" or "*Look! Look at that!*" - counterbalanced across all baseline trials). After 2 seconds, infants heard "*wow!*" to maintain their attention.

This baseline trial was then followed by a test trial which presented one of the test sentences, followed by a six-second-long presentation of the same pair of images that were presented in the previous baseline trial (with a 270-milliseconds pause between the end of the test sentence and the appearance of the images). Each image was presented on the same side as in the previous baseline trial. Test sentences were heard again 2 seconds into the image pair presentation.

Thus, each infant went through a test session which consisted of eight *baseline-test* trial cycles. Each of these cycles lasted approximately 24 seconds. An audio-visual attention-getter (i.e., a flashing, chiming, green circle) was used to direct infants' attention to the center monitor. This attention-getter appeared prior to the beginning of each of the *baseline-test* trial cycles. Each image in a pair served as the target image for half of the infants and as the distractor for the other infants. Infants saw each pair of images only once.

In order to control for side preference, the side in which the target image appeared was quasi-randomized within each test session. Therefore, in order to locate the referents, infants would often have to shift their gaze from one side to the other across the different trials and image pairs.

Table 3
A schematic illustration of the preferential-looking experimental procedure

Trial	Auditory Stimuli	Left	Center	Right
Attention Getter *(Flashes)*	***Bell chiming***			
Baseline Trials	***Look! Look at these/that***			
	Wow!			
Test Trials	***Can you see the ball?***			
	Can you see the ball?			

Coding. The videotaped sessions were transferred to a Macintosh G4 computer and converted into QuickTime® digital movies. Infants' looking behavior was coded off-line using the *SuperCoder* software (Hollich, 2003). This program creates a 30-frames-per second transcript of the test session and allows a frame-by-frame analysis of the infants' looking behavior.

Of the final sample of infants who were included in the study, there were seven missing test cells from four different 24-month-old infants' test sessions and from three different 18-month-old infants' test sessions, because during specific trials these infants were fussy or non-attentive (n = 5) or a technical problem prevented seeing where the infant was looking (n = 2).

An observer who was 'blind' to the experimental design of this study coded all sessions. A second (blind) observer coded six randomly chosen infants. The average correlation between the two observers was 0.999 for the 24-month-olds (range: 0.997-0.999), and 0.999 for the 18-month-olds (range: 0.999-0.999), hence indicating high inter-observer reliability.

6.1.2. *Results*

Attention Ratio. Infants' attention ratio during baseline and test trials was calculated in order to estimate their interest in the visual stimuli. This measure is based on the time an infant looked towards either image in a pair, divided by the overall six-second period in which the images were presented. The average attention ratio was 88.3% (SD = 9.2%) for the 24-month-old infants, and 84.2% (SD = 5.8%) for the 18-month-old infants. Hence, the infants in both age groups seemed to be highly attentive to the visual stimuli.

Vocabulary Reports. The parental reports on infants' estimated noun comprehension supported the assumption that infants were generally familiar with the nouns in the current design. Parents of the 24-month-old infants reported a noun comprehension average of 95.3% (*SD* = 6%; *Range* = 81% to 100%), while the 18-month-old infants were reported to be familiar on average with 83.59% (*SD* = 16%; *Range* = 50% to 100%) of the nouns (see *Table 1*).

Language production in both age groups followed Brown's (1973) developmental *Stage I*, which predicts an MLU of approximately 1.75 morphemes-per-utterance at 15 to 30 months (24-month-olds: *Mean MLU*= 1.09; *SD MLU* = 0.76; *Range MLU*: 0 to 4; 18-month-olds: *Mean MLU* = 0.43; *SD MLU* = 0.62; *Range MLU*: 0 to 2).

Only six 24-month-old infants and none of the 18-month-old infants produced FWs at all. Only four 24-month-old infants ever produced the article '*a*' (or *schwa*) and none produced '*the*'. Hence, infants in both groups had not fully mastered the production of language in general, or of FWs such as determiners in particular.

Statistical Analyses. In all of the statistical analyses mentioned henceforth in *Experiment 1*, *Experiment 2* and *Experiment 3*, there was no significant interaction involving *Sex* nor was a main effect for *Sex* found. For this reason, *Sex* was not included as a variable in the subsequent analyses.

First Look to Target. Mean proportion of correct first look differed with age and function word type. A statistical analysis using the *Generalized Estimating Equation* (GEE) logistic regression which included the combined 18- and 24-month-old infants' data, yielded a significant effect for *Function Word*, χ^2 (3) = 12.04, p =

.0073 and a marginal interaction between *Function Word* and *Age*, χ^2 (3) = 7.5, p = .058, ns.

As *Table 4* below demonstrates, this interaction between *Function Word* and *Age* approached significance (at the .05 level) most likely because the 18-month-old infants were less consistent as a group in comparison to the 24-month- old infants in orienting to the target image on their first look (immediately) following the grammatical sentences.

An analysis of the differences of least square means yielded significant differences in correct first look between THE vs. AND, χ^2 (1) = 13.43, p = .0002, and between THE vs. EL, χ^2 (1) = 6.63, p = .01. Moreover, NULL was significantly different from AND, χ^2 (1) = 4.53, p = .0333. The difference between NULL (65% correct first look) and THE (84% correct first look) was not significant, χ^2 (1) = 0.85, p = .35.

Table 4
Experiment 1: Percentage of cases in which infants' first look following test sentences was directed to the target image

		Function Word			
		THE	AND	EL	NULL
Age	18-month-olds	60 (18/30)	50 (16/32)	54.8 (17/31)	68.8 (22/32)
	24-month-olds	83.9 (26/31)	48.4 (15/31)	54.8 (17/31)	64.5 (20/31)
	Average	72.1 (44/61)	49.2 (31/63)	54.8 (34/62)	66.6 (42/63)

Note. Values enclosed in parentheses represent the number of correct first looks out of the overall number of test trials for a specific *Age* x *Function Word* combination.

Latency. As *Figure 1* demonstrates - for infants in both age groups - latency to target was the shortest following the grammatical sentences. Thus, the 19- and 24-month-old infants located the target image about three times faster in the grammatical condition than in any of the ungrammatical conditions.

A 4 (*Function Word*: THE vs. AND vs. EL vs. NULL) x 2 (*Age*: 24 months vs. 18 months) mixed-model analysis of variance (ANOVA) after a square root transformation yielded a significant effect of *Function Word*, F (3,31) = 3.63, p = .014, and no main effect or interaction with *Age*, F (3,206) = .753, p = .522.

Planned comparisons showed significant differences in latency between '*the*' and each ungrammatical condition: THE vs. AND, t (212) = -2.27, p = .007; THE vs. EL, t (212) = -2.94, p = .004; THE vs. NULL, t (212) = -2.28, p = .024. No significant differences among the ungrammatical conditions were found.

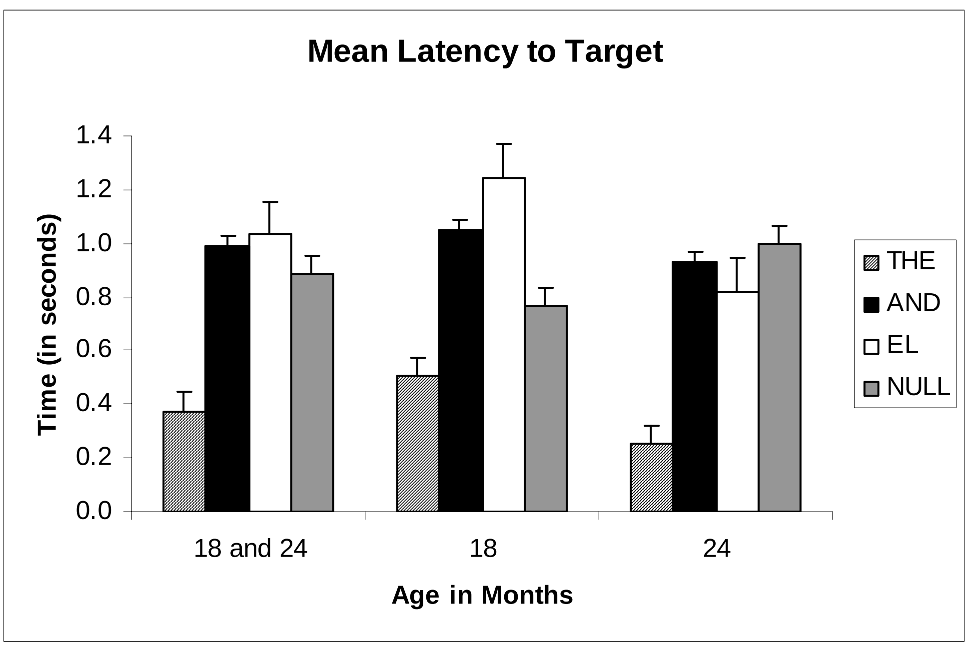


Figure 1
Mean latency to target in seconds (+ Standard Error) in *Experiment 1* as a function of *Age* (18- and 24-month-old infants) and *Function Word* ('*the*', '*and*', '*el*', '*null*').

Immediate Latency. This more constrained analysis of latency included only those cases (across all four test conditions and across all subjects) in which infants' first look was in fact directed towards the target image. This was the case in 78 trials out of a total of 124 test trials in the 24-month-old age group; and in 73 trials out of a total of 125 test trials in the 18-month-old age group.

If the target image is correctly identified on infants' first look, would the (linguistic) effect of the FW manipulation in the preceding test sentence still be noticeable?

As demonstrated in *Figure 2* (see below), and in accordance with the results in the general latency measure which are discussed above – the 18- and 24-month-old infants' latency to target was again the shortest following grammatical sentences with '*the*': THE: 0.132 seconds; AND: 0.239 seconds; EL: 0.208 seconds; NULL: 0.344 seconds. A 4 (*Function Word*: THE vs. AND vs. EL vs. NULL) x 2 (*Age*: 24 months versus 18 months) mixed-model ANOVA following a square root transformation yielded only a significant effect for *Function Word*, $F(3,31) = 7.41$; $p < .0001$. No main effect of *Age* was found, and no significant interactions involving *Age* were found.

Planned comparisons showed significant differences between the grammatical condition and each of the other three ungrammatical conditions: THE vs. AND, $t(119) = -2.67$, $p = .008$; THE vs. EL, $t(123) = -2.26$, $p = .026$; THE vs. NULL, $t(119) = -4.63$, $p < .0001$. A significant difference was also found between EL vs. *NULL*, $t(128) = -2.11$, $p = .036$.

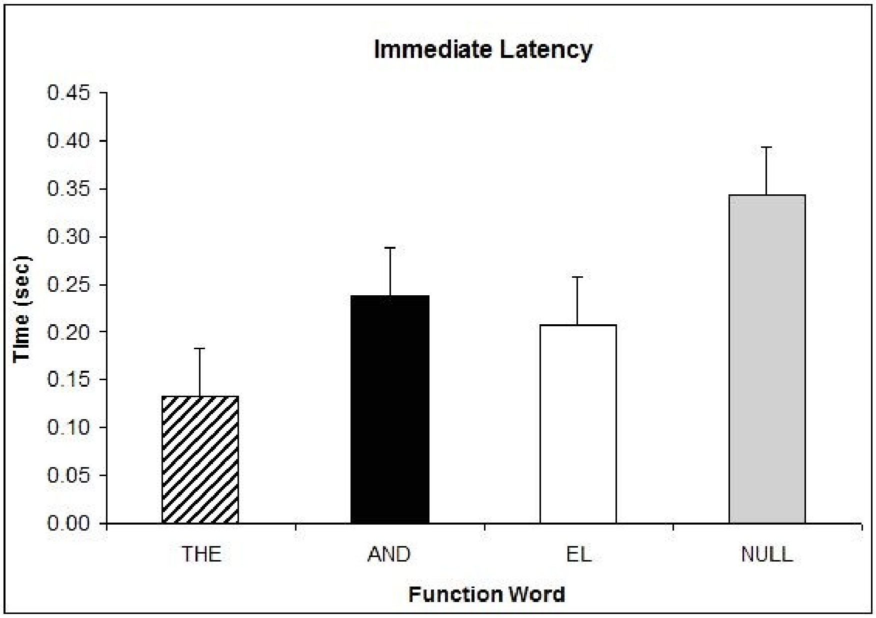


Figure 2
Mean immediate latency to target in seconds (+ Standard Error) for the 18- and 24-month-olds in *Experiment 1* as a function of *Function Word* (‘*the*’, ‘*and*’, ‘*el*’, ‘*null*’).

Thus, whether or not infants oriented to the target image first, both *Latency* analyses in *Experiment 1* show that the 18- and 24-month-old infants oriented to the target image significantly faster after hearing a test sentence using the determiner ‘*the*’ - than after hearing a test sentence with a nonsense FW (‘*el*’); a FW which was ungrammatical for the specific syntactic context (‘*and*’); or no FW at all (‘*null*’).

Proportion of Looking Time to Target. Infants’ PLT to the target image during the baseline trial (which was used to obtain a baseline measure of infants’ looking to both images) was compared to the test trial (which presented a FW and named the target image). Each of the four sentence types caused an increase in PLT to the target image in comparison to the preceding (non-linguistic) baseline trial, with the largest increase occurring in the grammatical condition: THE: 0.11 seconds; AND: 0.086 seconds; EL: 0.089 seconds; NULL: 0.082 seconds.

However, a 4 (*Function Word*: THE vs. AND vs. EL vs. NULL) x 2 (*Age*: 24 months vs. 18 months) mixed-model ANOVA did not yield any significant effects on this difference score. Therefore, the FW manipulation appeared to have no significant effect on infants' PLT to the target.

6.1.3. *Discussion*

Following a seminal study by Gerken and McIntosh (1993), *Experiment 1* attempted to further explicate the role of FCs - in particular, the English determiner '*the*' - in infants' sentence processing and noun reference determination at 18 and 24 months of age.

The current results replicate Gerken and McIntosh's essential findings with 24-month-olds, using however a different methodology (the IPLP); and also extend them to a younger age, 18 months. Specifically, the current results demonstrate that the 18-month-old infants as well as the 24-month-old infants were able to distinguish between two English FWs which belong to two different FCs (i.e., '*the*'/'*and*' - DP/CP; respectively); and seemed to identify their different grammatical functions in sentences. This ability was found to facilitate the infants' speed and accuracy in processing the linguistic input and in the establishment of a noun's reference, already at a developmental stage in which (English-learning) infants do not typically produce FWs correctly or consistently in their speech.

The design of this particular preferential-looking task provided a range of dependent variables which evidenced this ability. First, there were significant differences for the 18- and 24-month-old infants in both *Latency* analyses between the grammatical condition and all three ungrammatical conditions. Infants located the target image significantly faster after hearing sentences with the grammatically correct determiner (*the*) rather than the ungrammatical sentences which featured other types of FWs (‘*and*’, ‘*el*’) or no FW at all (‘*null*’).

In addition, the analysis of the *First Look* measure yielded significant differences between the grammatical condition (‘*the*’) and the two ungrammatical substitution conditions (‘*and*’, ‘*el*’). Infants looked more often at the target image on their first look after hearing sentences with a grammatical (‘*the*’) rather than an ungrammatical FW (‘*and*’, ‘*el*’).

These new findings provide more wide-ranging empirical evidence which demonstrates that English-learning infants are familiar with certain distributional and syntactic properties of the English determiner ‘*the*’ already by 18 months of age. The current findings also demonstrate how such linguistic awareness can aid infants in determining reference for noun phrases (NP).

Moreover, these findings indicate that already by 18 months of age, infants appear to be sensitive to the broader phrasal and sentential contexts in which a content word appears. That is, when processing a sentence, infants seem to be taking into account the specific FWs which appear in it (i.e., ‘*can you see* *<u>the/and</u>* *ball?*’), rather than merely focusing on the content words alone (i.e., *ball*).

6.2. *Experiment 2*

The results in *Experiment 1* suggest that English-learning infants of 18 and 24 months of age anticipated a determiner to precede a *Noun Phrase*; and that this information served them in locating a visual referent faster and more accurately than after hearing ungrammatical [FW + Noun] combinations.

Experiment 2 was thus designed to further pinpoint the developmental timeline in which certain FWs become grammatically functional for children in their syntactic computation of English sentences. In particular, *Experiment 2* explored whether already at 12 months of age, infants would be able to distinguish two different types of FWs - a determiner ('*the*') versus a conjunction ('*and*') – based on their different grammatical roles in English. Such evidence would strengthen the view that FCs have a critical role in underlying children's earliest sentence skeletons and in linking syntactic structures to their semantic meanings and referents.

Experiment 2 focused on infants of 12 months for two main reasons. First, to date, the youngest age in which infants have been reported to consult the grammatical function of FWs is 14 months (Höhle *et al*., 2004). As mentioned above, in Höhle *et al*.'s study, 14- to 16-month-olds categorized novel words into their appropriate syntactic category (i.e., a noun) based on the specific type of FWs which accompanied these novel words (i.e., *Determiners*). In contrast, a group of 12- to 13-month-olds failed on the same exact task.

By employing the current preferential-looking design, and by focusing on the English determiner '*the*' – which is the most common English word (Cutler & Carter, 1987; Paul & Baker, 1992) - *Experiment 2* was set to examine whether early sensitivity to the grammatical role of FWs (in English) may be detected in some form already at 12 months of age.

More generally, children's transition to the second year of life has been assumed to be a critical period in the acquisition of language, as several linguistic factors are integrated and reorganized in language processing. Several studies have shown that children demonstrate notable progress in their mastery of phonological and prosodic patterns of their native (acquired) language (e.g., Gerken, 1994; Werker & Yeung, 2005), which in turn advances their word learning and reference determination skills (e.g., Halle & de Boysson-Bardies, 1994; Pruden, Hirsh-Pasek, Golinkoff & Hennon, 2006; Swingley, 2005; Thierry, Vihman, & Roberts, 2003). Young children also use prosodic and phonological phrase boundaries as cues to segment the syntactic phrase boundaries in a sentence (e.g., Gerken *et al*., 1994; Gout *et al*., 2004).

In particular, major developmental effects characterize the acquisition of content word categories around the 1-year marker, just about the time when early first word productivity is most notable (Fenson, Dale, Reznick, Bates, Thal, & Pethick, 1994). For example, an array of behavioral and ERP studies by Werker and her colleagues (e.g., Mills, Prat, Zangl, Stager, Neville, & Werker, 2004; Stager & Werker, 1997; Werker, Fennell, Corcoran, & Stager, 2002; Werker & Yueng, 2005) have demonstrated that although the capability for fine phonetic discrimination appears to be present early in development (already during the first year of life), 1-year-old infants who are just beginning to explore the meanings and visual referents of words seem to neglect to some degree the earlier, fine-detailed phonological information they have possessed. Moreover, their ability to form associations between words and objects still depends to a large extent on perceptual, pragmatic and social cues such as visual salience and eye-gaze (Werker & Yueng, 2005).

Could early sensitivity to the reoccurring distributional patterns, as well as the grammatical role of FWs, possibly bootstrap and guide what seems to be a fragile and critical period in language development?

As mentioned above, such sensitivity could serve children in several ways (e.g., aiding the selection of a syntactic category for novel nouns and verbs; assisting word reference determination). Empirical evidence for such sensitivity would also critically challenge the hypothesis that in the early stages of language acquisition infants' access is limited only to lexical (content) categories (e.g., nouns, verbs). Instead, accessing FWs grammatically already at 12 months of age would suggest that both lexical (content) word categories as well as FCs are developing *concurrently* during this critical period in language acquisition.

To explore these questions, a group of 12-month-old infants were tested on the exact same task and stimuli as in *Experiment 1*, using the IPLP. As in Gerken and McIntosh's (1993) study and in *Experiment 1*, the experimental design in *Experiment 2* contrasted grammatical sentences in which the English determiner '*the*' preceded a noun (e.g., *Can you see the ball?*) versus three types of ungrammatical sentences in which '*the*' was replaced with a nonsense word ('*el*'), replaced with an English FW ('*and*'), or dropped ('*null*').

If infants' looking responses vary across these different types of sentences, several implications would arise regarding what is currently known about children's early representation and computation of FCs in language. First, if infants of 12 months already have a detailed phonetic encoding of a familiar and highly frequent FW such as '*the*' in their language, they should be able to distinguish it from an unfamiliar one which they have never heard before, and hence should demonstrate different looking responses to the grammatical condition versus the novel word condition ('*el*').

Second, different responses elicited by the grammatical condition versus the '*null*' (omitted-FW) condition would imply that infants are noticing the absence of an obligatory determiner which must precede a singular count noun in the specific type of sentence that was used in the current studies.

Lastly, and most importantly for the current studies' purposes - if infants' looking patterns vary between sentences using the English FWs '*the*' versus '*and*', it would demonstrate that infants are sensitive to the unique grammatical role which each of these FWs carries (i.e., '*and*' makes the specific sentence frame ungrammatical, e.g., *can you see and ball?*). Such evidence would indicate that already around one year of age, specific FCs (e.g., *Determiners*) are syntactically linked to their complement (e.g., a noun, or a *Noun Phrase*) and are therefore grammatically functional for the young child.

6.2.1. *Method*

Participants. Sixteen 12-month-olds (15 Caucasian, 1 African-American; 9 males, 7 females) participated. Infants had a mean age of 11 months and 18 days (*SD* = 14.47 days). All infants were full-term, healthy, had no history of auditory or visual impairment, and did not hear any other language but English on a regular basis.

Three additional infants (males) were not included in the final sample due to fussiness or non-attentiveness throughout most or all of the test session ($n = 2$) or a technical failure ($n = 1$). Participants were recruited through a letter given to parents at the time of their child's birth. All infants, regardless of their performance on the task, received a small toy in appreciation of their participation.

Stimuli. The visual stimuli were identical to those used in *Experiment 1*, consisting of 16 color images of objects and animals (see the *Appendix*). As in *Experiment 1*, images were paired according to their reported familiarity proportion among 16-month-old English-learning infants based on the MCDI lexical norms (Dale & Fenson, 1996) so that each pair of images had approximately the same familiarity proportion (see *Table 1*). The auditory stimuli were exactly the same sentences that were used in *Experiment 1*. In addition, the apparatus and procedure also matched exactly those in *Experiment 1*.

Coding. The average correlation between two independent codings of six randomly chosen infants was 0.999 (range: 0.997 to 1.000). Seventeen missing test cells from ten different infants' test sessions were excluded from the final analyses due to fussiness or non-attentiveness (n = 15) or a technical problem that prevented seeing where an infant was looking (n = 2).

6.2.2. *Results*

Attention Ratio. The 12-month-olds' overall mean attention ratio which was recorded during the test sessions (i.e., including both baseline and test trials) indicates high attention to the visual stimuli: *Mean* = 77.3%; *SD* = 8%; *Range* = 7.4% - 99.4%.

Vocabulary Reports. The parental reports which were collected in order to estimate the 12-month-olds' familiarity with the nouns that were used in the study indicated low infant familiarity levels: *Mean* = 23.44%; *SD* = 18.61%; *Range* = 0% to 56.25%.

First Look to Target. As demonstrated in *Table 5* below, the mean proportion of correct first look to target was not considerably different across the four test conditions: THE: 51.9% (14 correct looks to target out of a total of 27 looks); AND: 48.3% (14/29); EL: 34.6% (9/26); NULL: 51.7% (15/29). A *Generalized Estimating Equation* (GEE) logistic regression analysis for the effects of *Function Word* on correct first look failed to yield a significant effect for *Function Word*, χ^2 (3) = 2.41, p = .49 - or any other significant differences among the four test conditions.

Table 5
Experiment 2 and Experiment 3: Percentage of cases in which the 12-month-old infants' first look following test sentences was directed to the target image

	Function Word			
	THE	AND	EL	NULL
Experiment 2	51.9% (14/27)	48.3% (14/29)	34.6% (9/26)	51.7% (15/29)
Experiment 3	69.2% (18/26)	46.4% (13/28)	48.3% (14/29)	46.4% (13/28)

Note. Values enclosed in parentheses represent the number of correct first looks (i.e., directed to target) out of the overall number of test trials for each type of *Function Word*.

Latency to Target. As *Figure 3* (see below) indicates, infants' latency to target differed among the four test conditions. Particularly, as with the older age groups (i.e., the 18- and 24-month-old infants) that were tested in *Experiment 1* - the 12-month-old infants in *Experiment 2* displayed the shortest latency to target following the grammatical sentences: THE: 1.317 seconds; AND: 1.989 seconds; EL: 2.161 seconds; NULL: 1.465 seconds.

However, a mixed-model analysis of variance (ANOVA) failed to yield a significant effect for *Function Word*, F (3,43) = 1.13, p = .347. Planned comparisons among the four sentence types were also not significant.

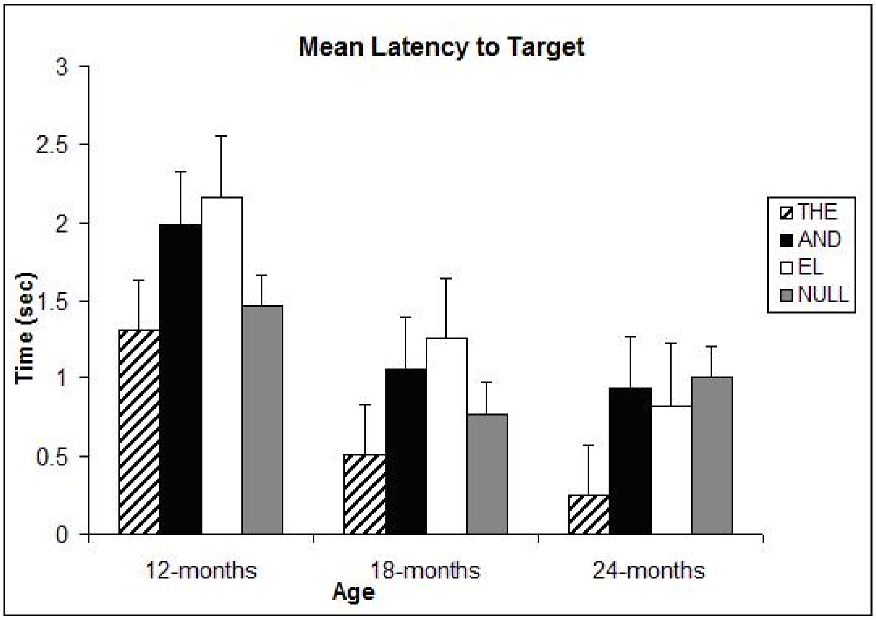


Figure 3
Mean latency in seconds (+ Standard Error) to the target image as a function of *Age* (12-, 18- and 24-month-old infants) and *Function Word* ('*the*', '*and*', '*el*', '*null*').

Immediate latency. Infants' first look was directed towards the target image (across all conditions) in only about half of the cases (N = 59). This small sample size was a challenging factor in the analysis, especially because all but three 12-month-old infants had at least one case in which they did not look to the target image in both test trials covering a specific type of FW (e.g., *el ball, el cat*) - hence eliminating any data for this condition. Although different averages in latency to target were recorded (THE: .323 seconds; AND: .198 seconds; EL: .481 seconds; NULL: .721 seconds) - a mixed-model ANOVA did not yield a significant effect for *Function Word*, F (3,48) = 1.03, p = .384. Planned comparisons among the four sentence types were also non-significant.

Difference in PLT to Target from Baseline to Test Trials. Of the four test conditions, only '*the*' increased PLT to target in test trials versus the preceding baseline trials: THE = 6.4%; AND = -0.1%; EL = -0.3%; NULL = -0.5%. However, a mixed-model ANOVA did not yield a significant effect on this difference score, F (3,96) = .589, p = .624. Planned comparisons among the 4 conditions were not significant.

6.2.3. *Discussion*

The results in *Experiment 2* with 12-month-old infants did not seem to fully replicate those in *Experiment 1* with 18- and 24-month-olds. First, in general, the 12-month-old infants' responses were slower and less accurate in comparison to the older infants tested in *Experiment 1*. Specifically, the 12-month-olds were not as attentive during test sessions; took more time in orienting to the target image after hearing the test sentences; and were not as successful in locating the target image on their first look.

Second, although some of the 12-month-olds' looking patterns did closely match those of the older age groups in *Experiment 1* (i.e., in the latency and PLT measures; see *Figure 3*) - the statistical analyses were not significant. This may indicate that the 12-month-olds were unaware of the different grammatical roles of '*the*' and '*and*' in English.

Alternatively, some aspects in the current design may have distracted the infants, thus possibly misrepresenting their actual linguistic competence. In fact, the results in *Experiment 2* are somewhat surprising because they do not accord with previous research which indicated that already the first year of life, FWs are detected and distinguished from content and nonsense words (e.g., Höhle & Weissenborn, 2003; Shafer *et al*., 1998; Shi *et al*., 1999).

However, in *Experiment 2*, even when an unfamiliar word such as '*el*' was contrasted with a highly frequent and a phonetically well-represented article such as '*the*', no different looking patterns were recorded. Therefore, these results may be due to the fact that the 12-month-olds did not know the nouns as well as the 18- and 24-month-olds in *Experiment 1*. As mentioned above, the nouns originally chosen for use in *Experiment 1* were based on the lexical norms of the MCDI at 16 months. Although replicating the exact set of nouns was favorable for reasons of consistency, it may have harmed the validity of the current results. In addition, the parental reports that were collected on the 12-month-olds' estimated comprehension of these nouns also suggest that infants were unfamiliar with many of the nouns they were presented with (see *Table 1*).

In sum, the non-significant results in *Experiment 2* may reflect the 12-month-old infants' unfamiliarity with the specific nouns that were used in the current design rather than their actual grammatical proficiency regarding FWs.

6.3. *Experiment 3*

This follow-up experiment investigated whether the non-significant results in *Experiment 2* reflected the 12-month-old infants' insensitivity to the manipulation of a single FW (i.e., the English determiner '*the*') in a sentence; or whether such sensitivity may in fact be apparent by 12 months of age. Thus, *Experiment 3* was designed to explore whether given some changes in the experimental design - taking into account the more limited knowledge and access to the lexicon that infants have at this age - infants could distinguish the FW manipulation in the three ungrammatical conditions and the syntactic anomalies that resulted from this manipulation (e.g., '*Can you see and cat?*').

Experiment 3 differed from the original design used in *Experiment 1* and in *Experiment 2* in three ways. Most importantly, a pre-test *Familiarization* phase was added to the experimental procedure in order to increase the likelihood that infants would be familiar with the appropriate linguistic label (i.e., a noun) for each of the images with which they were presented. Therefore, infants were now first introduced with each of the pair of images they were about to see in the subsequent baseline and test trials. During familiarization, each image was presented separately three times accompanied by its linguistic label.

Second, to further ensure the 12-month-old infants' familiarity with the test nouns as well as their respective images, only eight nouns (instead of 16) were now used. These eight nouns were divided into four pairs, with each pair of images presented twice to the infant (see *Method*, below).

Lastly, the PLT measure in *Experiment 2* (as well as in *Experiment 1*) possibly failed to capture infants' grammatical competence because test trials were too long (six seconds). Although infants could have been initially distracted by an ungrammatical sentence - their looking patterns during the rest of the test trial were not closely related to the FW manipulation. Zangl and Fernald (2003) ran a preferential-looking study on the basis of Gerken and McIntosh's (1993) original design and found a significant difference in PLT between the grammatical versus the nonsense-FW condition. In their study, images were presented for only 3 seconds. Therefore, in *Experiment 3*, duration of image presentation in the baseline and test trials was reduced to four seconds.

6.3.1. *Method*

Participants. Sixteen infants (seven females, nine males) participated. Parents reported thirteen infants as Caucasian, two as Caucasian/Asian, and one as Hispanic/Latino. The mean age (months; days) was 11;20 (*SD* = 12.5 days). All infants were reported as full-term, healthy, with no history of auditory or visual impairment, and hearing only English on a regular basis (only one infant was reported to also hear 20% Bengali). All infants, regardless of their performance on the task, received a small toy in appreciation of their participation. Three additional infants (one female, two males) were not included in the final sample due to fussiness or non-attentiveness throughout most or all of the test session ($n = 2$), or failure to complete the test session ($n = 1$).

Stimuli. Only eight images (from the original set of 16 images used in *Experiments 1* and *2*) were used as visual stimuli in *Experiment 3*: a ball, book, car, cat, cup, dog, phone, and a shoe (see the *Appendix*). The images were paired into four pairs (ball-book, cat-dog, cup-phone, car-shoe) according to their reported MCDI familiarity proportion among 12-month-old English-learning infants, so that each pair of images had approximately the same familiarity proportion (see *Table 6*).

Table 6
Experiment 3: Mean percent of infant familiarity at 12 months with the test nouns according to the *Macarthur-Bates Communicative Development Inventory*; and the estimated mean percent of infant familiarity with these nouns at 12 months, according to the parental reports that were collected.

Pair	Nouns	MCDI: Lexical Norms	Parental Report		
			"*Yes*"	"*No*"	"*Not Sure*"
1	Phone	58	37.5	18.75	43.75
	Cup	55.7	50	25	25
2	Ball	79.5	62.5	12.5	25
	Book	68.2	62.5	6.25	31.25
3	Cat	45.5	31.25	31.25	37.5
	Dog	69.3	43.75	25	31.25
4	Car	53.4	37.5	31.25	31.25
	Shoe	62.5	31.25	43.75	25

The auditory stimuli were also a subset of the nouns and sentences that were used in *Experiment* 1 and in *Experiment 2*. Eight nouns relating to the images mentioned above were presented separately during familiarization trials. During baseline trials, two of the original carrier phrases were used (i.e., "*Look! Look at these!*" and "*Wow!*"). The test sentences were also identical to those originally used in *Experiment* 1 and in *Experiment 2*. However, only those 32 sentences in which the eight nouns mentioned above appeared were included in *Experiment 3*.

Procedure. Infants were randomly assigned to view one of four sentence lists, with four infants (two males, two females[18]) receiving each list. Each list was composed of eight sentences, with two sentences of each kind of FW (*grammatical*; *ungrammatical*; *nonsense*; *null*). Order of appearance of the four sentence types was quasi-randomized across lists.

Each child was presented with eight consecutive test cycles in which a familiarization trial was followed by a baseline trial and then a test trial. Thus, infants were overall presented with 24 trials (8 Familiarization; 8 Baseline; 8 Test). Each *Familiarization-Baseline-Test* cycle lasted 40 seconds, hence making the entire session last six minutes.

A flashing, chiming, green circle serving as an attention getter appeared on the center monitor prior to the beginning of each of the eight *Familiarization-Baseline-Test* cycles. During the familiarization trials, two images (e.g., *ball*, *book*) were presented separately and successively on the center monitor. Each image was presented three times for 4 seconds. For example: '*Ball*'; '*Book*'; '*Ball*'; '*Book*'; '*Ball*'; '*Book*').

[18] List #4 was an exception with three males and one female.

As in *Experiment 1* and *Experiment 2*, during the subsequent baseline and test trials, the same two images were presented simultaneously on the side monitors. However, infants now saw each pair of images twice during the test session. After the first four test trials, infants viewed the same pairs again in the same order. Each image in a pair served as the target image in one test trial and as the distractor in the other test trial in which that pair of images appeared.

To control for side preference, the side in which the target image appeared was quasi-randomized across test sessions in the following order: Left; Left; Right; Right; Left; Right; Left; Right. Therefore, infants who were in fact orienting to the target images based on the linguistic input would often have to shift their gaze from one side to the other across the different image pairs. In addition, to avoid a possible recency bias in infants' looking behavior during the baseline and test trials - based on whether the last image seen during familiarization was the target image or the distractor - the order of image presentation during familiarization was quasi-randomized as well.

Images seen last during familiarization trials were presented in the following order: Target; Distractor; Distractor; Target; Distractor; Target; Target; Distractor. Thus, there was no direct relation between which image appeared last during familiarization and which image served as target during the subsequent baseline and test trials.

Coding. Of the final sample of infants included in *Experiment 3*, there were 18 missing test cells from ten different infants' test sessions, because during specific trials, these infants were fussy or non-attentive (n = 16) or a technical problem prevented the experimenter from seeing where the infant was looking (n = 2). The average correlation between two coders was 0.996 (range: 0.991 to 0.998), hence indicating high inter-observer reliability.

6.3.2. *Results*

Attention Ratio. Infants' overall mean attention ratio during test sessions in *Experiment 3* was 71.6% (*SD* = 15%; *Range* = 22.3% – 98.3%). This suggests that the 12-month-old infants were relatively attentive to the stimuli they were presented with.

Vocabulary Reports. The parental reports which were collected to estimate the 12-month-old infants' familiarity with the nouns that were used in *Experiment 3* indicated relatively low familiarity levels: *Mean* = 44.5%; *SD* = 12.7%; *Range* = 31.25%-62.5%.

First Look to Target. As *Table 5* demonstrates, different mean proportions of correct first look were found among the four conditions in *Experiment 3*. In particular, the results indicate that as was the case in *Experiment 1* with the 18- and 24-month-old infants, the grammatical condition ('*the*') initiated considerably more correct first looks in comparison to each of the three ungrammatical test conditions: THE: 69.2% (18 correct looks to target out of a total of 26 looks); AND: 46.4% (13/28); EL: 48.3% (14/29); NULL: 46.4% (13/28).

However, a *Generalized Estimating Equation* (GEE) logistic regression analysis for the effects of *Function Word* on correct first look to target did not yield a significant effect for *Function Word*, χ^2 (3) = 4.51, p = .21. Planned comparisons among the grammatical condition and each of the three ungrammatical conditions did not reach statistical significance: THE vs. AND, χ^2 (1) = 2.3, p = .13; THE vs. EL, χ^2 (1) = 3.51, p = .06; THE vs. NULL, χ^2 (1) = 2.97, p = .08.

Latency. As in *Experiment 1* and *Experiment 2* - infants' latency to target was the shortest following the grammatical sentences (see *Figure 4*). Thus, the 12-month-old infants in *Experiment 3* oriented to the target image about twice as fast than in any of the ungrammatical conditions. Planned comparisons among the four types of sentences showed significant differences between '*the*' and the two ungrammatical FW-substitution conditions: THE vs. AND, t (106) = -2.21, p = .029; THE vs. EL, t (106) = -1.97, p = .05. The comparison between THE vs. NULL was not significant, t (106) = -1.51, p = .13.

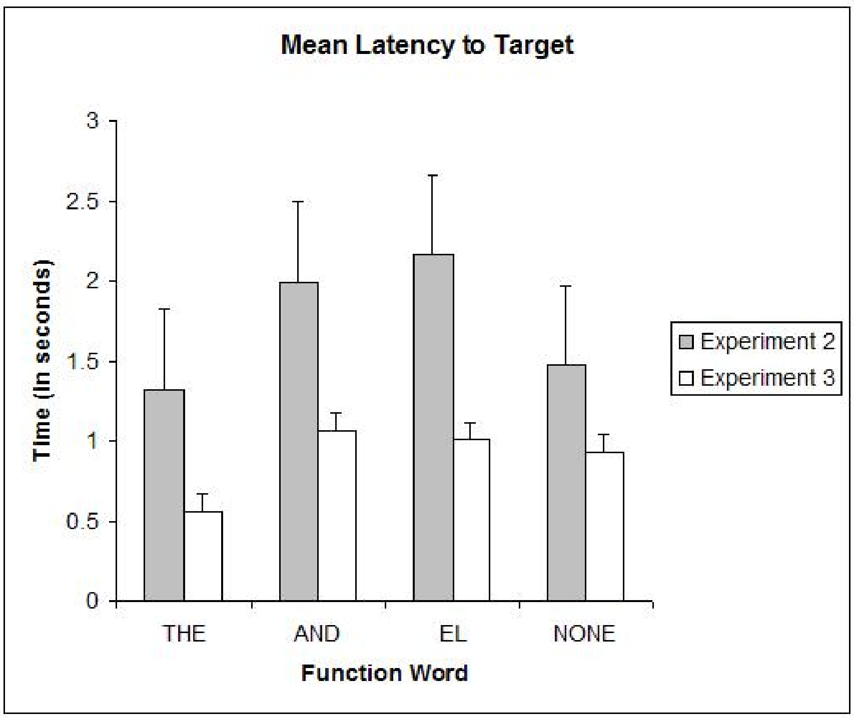


Figure 4
Mean latency in seconds (+ Standard Error) to the target image for the 12-month-olds in *Experiments 2* and *3* as a function of *Function Word* ('*the*', '*and*', '*el*', '*null*').

Immediate Latency. As in *Experiment 2*, infants' first look was directed towards the target image in only about half of the cases (N = 58), hence limiting the effectiveness of this analysis (most infants had at least one case in which they did not look to the target image in both test trials covering a specific type of FW). Although different latency averages were recorded (THE: .345 seconds; AND: .348 seconds; EL: .348 seconds; NULL: .315 seconds), no significant differences were found among the sentence types.

Proportion of Looking Time to Target. Each of the four sentence types caused an increase in PLT to target in comparison to the preceding (non-linguistic) baseline trial. The largest increase occurred in the grammatical condition: THE: 0.11 seconds; AND: 0.086 seconds; EL: 0.089 seconds; NULL: 0.082 seconds. However, a mixed-model ANOVA did not yield any significant effects among the four sentence types on this difference score.

6.3.3. *Discussion*

The results in *Experiment 3* suggest that the 12-month-old infants detected the FW-manipulation and were hence able to distinguish the grammatical versus the ungrammatical conditions. Specifically, the *Latency* analysis yielded significant differences between the grammatical condition and the two ungrammatical substitution conditions ('*and*', '*el*'). Infants located the target image significantly faster after hearing sentences with '*the*' rather than sentences with '*el*' or with '*and*'.

Although the *First Look* analysis did not yield significant results, it seems to support the above conclusion. Specifically, correct first look to target was much higher following grammatical sentences, and planned comparisons among the grammatical condition and each of the ungrammatical conditions approached statistical significance.

As *Figure 4* demonstrates, adding a familiarization phase had a crucial impact on the infants' ability to succeed in the task, most likely because they had now formed a more solid association between the noun labels and their visual representations[19]. Importantly, adding a familiarization phase did not only result in significant differences between the grammatical and the ungrammatical conditions, but infants' latencies were now shorter across the board for all four types of sentences. This adds further support to the suggestion that the insignificant results in *Experiment 2* were in fact a result of infants' insufficient familiarity with the specific nouns that were used, rather than being unable to detect the FW manipulation.

6.4. *Summary of the Empirical Findings*

The results in the studies described above with 12, 18 and 24-month-old infants converge with previous studies in the study of language acquisition, which documented children's early sensitivities to FCs. On the one hand, they converge with studies that document infants' early detection of FWs in the speech stream (e.g., Gerken *et al*., 1990; Höhle & Weissenborn, 2003; Shafer *et al*., 1998; Shi *et al*., 1999; Zangl & Fernald, 2003). In addition, these findings converge with other studies that provided evidence that infants can also access the grammatical function of certain FWs the language they are acquiring (e.g., Gerken & McIntosh, 1993; Höhle *et al*., 2004; Shady, 1996).

[19] These associations could be based (for specific infants and specific nouns) on a fast-mapping mechanism in which a novel linguistic label was associated with an image. Alternatively, infants may have consulted their recognition memory, that is, using the familiarization phase as a trigger to their previous knowledge of the lexicon. In both cases, the consequent effect was that the infants did much better on the task.

Moreover, the current results further our knowledge regarding the nature of children's early sensitivity to FCs and its developmental timeline. There are several reasons (based on the current design) to support the claim that the different looking patterns demonstrated by the infants must have resulted not only from the infants' ability to distinguish the specific FWs which were contrasted in this study based on their phonological and distributional patterns; but also from the incorporation of these words in infants' *syntactic* processing of the test sentences.

First, if we examine the pair of English FWs which were used, there are in fact many expressions in English in which the conjunction '*and*' is followed by a noun (e.g., '*cookies and milk*', '*Bat and ball*', '*Sea and sun*', '*Mommy and daddy*'). That is, local distributional productivity of [FW + Noun] occurs with this FW, '*and*', as well as with the determiner '*the*'. Hence, distributional productivity alone cannot fully account for the infants' distinction of the sentences which have used '*and*' versus '*the*'.

Moreover, since the conjunction '*and*' may and does precede a noun in English, then if local distribution was the only factor contributing to the infants' distinction between '*the*' and '*and*', we would expect '*and*' to be differentiated not only from '*the*', but from the other ungrammatical FW condition ('*el*') as well. In other words, one would expect the infants to respond differently to a combination of '*and*' followed by a noun in comparison to a combination of a noun and a novel word to which they were never exposed before.

However, the infants treated the two ungrammatical substitution conditions ('*and*', '*el*') equally (and in the case of the 18- and 24-month-olds, the '*null*' condition as well) - and only discriminated between these conditions versus the grammatical condition ('*the*').

Furthermore, the interrogative sentence structure that was used maintains a grammatical structure until the noun is heard (i.e., both "*Can you see and*…" and "*Can you see the*…" are possible sequences in English). The fact that infants noticed that sentences such as "*Can you see and ball?*" are ungrammatical (or 'different'), while sentences such as "*Can you see the ball*?" are not, implies that they must have detected that a combination of a verb followed by '*and*' (e.g., "*... see and...*") does not allow a noun complement in this context. Therefore, the 12-, 18- and 24-month-old infants must have computed the entire syntactic structure of the sentence rather than only the noun (or NP) at the sentence end.

In sum, the current findings add further support to the hypothesis that FCs provide an early syntactic framework for the child's language acquisition in general, and to the developing interface between semantics and syntax in particular. These new findings shed light on the developmental course that underlies this knowledge and demonstrate that the child may access certain FWs based on their grammatical function already at 12 months of age.

Thus, lexical items such as nouns and verbs cannot be the only factor that young children rely on in their representation and computation of language. Instead, to some degree, content word categories may be dependent on and mediated by functional word categories.

CHAPTER 7

SUMMARY AND CONCLUSIONS

The current research program explored the status of *Functional Categories* (FCs) in early child language. Specifically, the preferential-looking design which was used in the present set of studies with 12, 18-, and 24-month-old infants contrasted a grammatical type of sentence using the English determiner '*the*' versus three ungrammatical types of sentences in which '*the*' was substituted by another English FW ('*and*'), an unfamiliar (nonsense) word ('*el*'), or an omitted-FW condition ('*null*'). The results indicated that in all three age groups - infants treated differently the grammatical condition as opposed to the ungrammatical conditions. Following grammatical sentences, infants were generally more accurate in locating a target image on their first look towards the images, and in addition demonstrated shorter latencies to target.

The next sections address the current findings in detail and aim at explaining their theoretical significance for the study of language acquisition. In addition, I address some broader issues that were raised in *Chapter 2* regarding the general role of FCs in language, in light of the current findings. Finally, I am suggesting additional steps which seem necessary for furthering the study of FCs in language acquisition.

7.1. *Theoretical Implications of the Current Findings*

The present findings, based on the performance of 12-, 18- and 24-month-old infants on the preferential-looking task mentioned above, critically challenge several hypotheses regarding the developmental course that children follow in the acquisition of language, in which the role of FCs has been described as very limited, or in some cases – non-existent. Such proposals have generally emphasized the role of *content* words at early stages in the acquisition of language (e.g., Bowerman, 1973; Grimshaw, 1981; Macnamara, 1982; Pinker, 1982, 1984; Radford, 1997; Schlesinger, 1971, 1981; Tomasello, 2000a,b, 2002).

Contrary to these proposals, the current findings provide experimental evidence suggesting that functional elements are not only detected by the young child; but also play a primary role in children's syntactic computation and online processing of sentences, already at 12 months of age. Moreover, in accordance with current syntactic theory, which grants FCs a crucial role in the (adult's) representation of language - these findings seem to provide empirical evidence that functional elements are also part of young children's representation of language.

7.1.1. *Integration of Multiple Cues*

What can explain the main result in the current studies, namely, the demonstrated ability of 12-, 18- and 24-month-old infants to distinguish sentences which have used two legitimate, highly-frequent English FWs ('*the*', '*and*'); and the major effect this ability had in facilitating infants' sentence-processing and in locating a noun's referent?

As discussed in *Chapter 4*, it has been previously demonstrated that from around the 1-year marker and throughout children's second year of life - several fundamental aspects of language (i.e., phonology, prosody, syntax and semantics) are integrated and reorganized in infants' representation and processing of language.

How could such integration of multiple cues (each relating to a different aspect of language) bring about a detailed grammatical sensitivity to specific FWs already at 12 months of age, as the current results indicate? The present findings and design suggest that the 12-, 18- and 24-month-old infants were in fact consulting several aspects of language - including certain syntactic properties - in processing the test sentences, and in particular, in attending to the FW manipulation in those sentences.

First, the infants must have consulted their previously acquired phonological and prosodic encoding of English FWs (as well as content words). As mentioned above, infants have been generally shown to acquire such fine-detailed phonological and prosodic knowledge regarding their native language already during their first year of life (and beyond) by attending to several acoustic characteristics which FWs typically share (e.g., monosyllabic, unstressed; see for example: Gerken *et al*., 1990; Seidl & Johnson, 2006; Shi *et al.*, 1998). Specifically, already at early stages in the acquisition of language – before one year of age - infants have been shown to segment FWs from continuous speech and to distinguish FWs from content words as well as from nonsense words (e.g., Gerken *et al*., 1990; Johnson, 2004, 2005; Shafer *et al*., 1998; Shi *et al*., 1999, 2006a,b).

This documented level of infant familiarity with the English lexicon seems to provide a plausible explanation for the significant differences between the grammatical condition ('*the*') and the nonsense-FW condition ('*el*') which were found in *Experiment 1* (18- and 24-month-old infants) and in *Experiment 3* (12-month-old infants). Thus, the 12-, 18- and 24-month-old infants' delayed response pattern following sentences in which '*el*' was used could be based on their unfamiliarity with this novel (non-English) word. In contrast, these infants must have already formed (by 12 months of age) a fine-detailed phonetic representation for the English determiner '*the*'[20].

[20] A distribution-based explanation is also possible, that is, '*el*' having a low transitional probability to occur as a separate word in an English sentence. However, the point here is that even a reliance on phonetic encoding alone would be sufficient for the infants to successfully distinguish '*el*' vs. '*the*' in this case.

7.1.2. *No segmentation of Function Words from Speech?*

One possible claim regarding the current findings is that they do not reflect infants' attentiveness to FWs *per se* in sentence processing. Alternatively, infants' responses could have resulted from rote memorization based on their previous experience with specific combinations of the determiner '*the*' with each of the nouns that were used in the current study. According to such view, infants would memorize sound sequences such as '*theball*' or '*thebook*' and treat them differently from novel sequences such as '*elbook*'.

However, infants' documented sensitivity to phonetic detail in speech already during the first year of life makes it unlikely that the 12-month-olds who were tested in the current experiments had represented the noun phrase at the end of the test sentences (e.g., '*the ball*') as one memorized unit[21]. Instead, as was also found in previous studies (e.g., Halle *et al*., submitted; Saffran, 2001), the infants must have separated FWs from content words as they were processing the different [*FW + Noun*] combinations.

In addition, specifically regarding the 12-month-old infants who were tested in *Experiment 2* and in *Experiment 3*, it should be noted that according to the MCDI inventories (for the age of 12 months) as well as the parental reports that were collected - many of the participating infants must have been unfamiliar with a large number of the test nouns which were used. Therefore, it seems improbable that these infants could hold a memorized representation of '*the*' along with the test nouns (as one memorized word or sequence), but neglect to have such specific memory for the nouns by themselves.

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[21] In addition, as described above, to avoid such scenario, all test sentences were carefully edited so that each word would be clearly separated from the ones it precedes or follows.

7.1.3. *Detecting Transitional Probabilities in Speech*

Infants' detailed phonetic representation of particular FWs, although a necessary factor for analyzing all of the four types of test sentences in the current design, would not be however sufficient for distinguishing the critical contrast between '*the*' and '*and*'. Thus, given that both these words are well-formed and extremely frequent in English, and since each of these FWs may be followed by a noun in English – it follows that merely recognizing the different sound structures of '*and*' versus '*the*' should not have resulted in infants' different looking behaviors in response to the test sentences.

Therefore, in order to distinguish sentences contrasting '*and*' versus '*the*', infants must have consulted additional linguistic components. One such major component is most likely infants' well-documented sensitivity to a variety of transitional probabilities and co-occurrence patterns in their linguistic input; and their ability to infer information regarding the structure and categorization of words in their language based on such sensitivity (*Statistical Learning*; e.g., Mintz, 2006; Saffran, 2001). Specifically regarding FWs, previous research revealed infants' early sensitivity to the purely distributional uses (i.e., without reference) of certain functional elements in the speech stream (e.g., Mintz, Newport, & Bever, 2002; Shady, 1996; Swingley, 2005) - in fact, already during infants' first year of life (e.g., Höhle & Weissenborn, 2003; Shafer *et al*., 1998).

Consequently, infants' performance on the current task was most likely based in part on their awareness of the frequency and co-occurrence patterns of '*and*' and '*the*' in English - in particular, the high frequency in which determiners and nouns co-occur (e.g., '*the ball*', '*the big house*', '*a dog*') in comparison to co-occurrences of ['*and*' + *Noun*]. This early sensitivity, that is, 1- to 2-year-old infants' sensitivity to co-occurrence patterns between specific function and content words, suggests that early linguistic computation is not restricted to content words alone (i.e., with FWs not detected or being ignored). Instead, these findings demonstrate that FWs are part of infants' developing vocabulary and play an active role in guiding infants' processing of sentences.

As mentioned above, such evidence also converges with experiments with adults in which subjects were dependent to a large extent on the occurrence of FWs in sentence processing tasks in natural and artificial languages (Cutler, 1993; Frigo & McDonald, 1998; Gomez & Gerken, 2000; Gomez & LaKusta, 2004; Green, 1979; Valian & Coulson, 1988).

7.1.4. *Early Grammatical Functionality of Function Words*

Yet, the current findings do not seem to be adequately explained solely on the basis of the different local distributions of '*the*' and '*and*' in spoken English, for a number of reasons. First, phrases and expressions which combine '*and*' with a noun may (and do in fact) occur relatively often in English (e.g., *mommy and daddy*; *bat and ball*; *sea and sun*; *cats and dogs*; *cookies and milk*). If infants encounter both these types of phrases (i.e., '*the*' + *Noun*; '*and*' + *Noun*) regularly in their linguistic input, why should they be distracted merely by hearing an utterance in which a noun is preceded by '*and*'?[22] (e.g., '*can you see and book?*').

Moreover, if infants would only rely on local transitional probabilities to process the test sentences, one would expect the looking responses following '*and*' to be different not only from '*the*', but also from '*el*' - a novel word which the infants have never heard before, neither separately nor with a noun.

[22] A general question is whether merely noticing a low transitional probability (i.e., such as '*and*' + noun] would suffice to distract infants so significantly as it did on the current reference-finding task (i.e., as opposed to detecting and processing a *syntactic* anomaly).

However, rather than showing such a gradual, frequency-based pattern of response (i.e., with sentences using '*the*' eliciting the fastest looking responses; followed by the less-frequent ['*and*'+ *Noun*] combinations; and lastly, sentences with the unfamiliar word '*el*') – infants seemed to have grouped the ungrammatical conditions together, and only discriminated between these conditions and the grammatical condition '*the*'. Thus, consulting the transitional probability of ['*and*' + *Noun*] combinations in the linguistic input does not seem sufficient to explain the infants' performance on the task, that is, discriminating between the '*the*' versus '*and*' conditions.

Lastly, notice that in order to detect the critical contrast between '*the*' and '*and*', infants must have processed the entire sentence template used in the current design. As mentioned above, both '*and*' and '*the*' may take a noun complement and so could not be distinguished solely on this basis in the current design[23]. In addition, notice that the sentence structure which was used in the current experiments maintains a possible grammatical structure until the noun is heard, that is, both "*Can you see and…*" and "*Can you see the…*" are legitimate sequences in English, which could be differentiated only by the type of complement they may allow (i.e., '*the*' – noun; '*and*' – verb).

Therefore, the infants' demonstrated ability to discriminate '*and*' versus '*the*' sentences suggests that they were aware not only of the [FW + Noun] combination - but also that a combination of a verb (i.e., '*see*') followed by '*and*' does not allow a noun complement in this context (e.g., "*…see and ball*")[24].

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[23] In English, '*and*' typically precedes only proper names (e.g., *daddy*) or nouns in the plural form (e.g., *dogs*). If infants distinguished '*the*' versus '*and*' sentences based on this information it would demonstrate a fine-detailed familiarity with the grammatical role of the conjunction '*and*'. However, the current design did not use such exemplars and hence such claims would need to be tested separately and more directly.

[24] But would allow for another verb to occur, for example, '*Can you see and speak*?'.

To summarize, the current design and results indicate that the 12-. 18- and 24-month-old infants most likely integrated both their (i) phonological and distribution-based sensitivities to co-occurrence patterns which characterize the words '*the*' and '*and*' in English phrases and sentences; as well as some awareness of (ii) the different *grammatical* functions which these words carry in English – as they were tested on the preferential-looking task.

As mentioned above, there is now ample cross-linguistic evidence suggesting that already during their first year of life, infants closely attend to phonological, prosodic and distributional cues and patterns in the linguistic input. That is, infants are able to detect specific words – that is, both content and function words - as well as specific combinations of words which appear in sentences in the language(s) they are acquiring.

What the new findings presented in this dissertation suggest is that when infants become sufficiently familiar with certain FWs in the linguistic input in terms of their phonetic structure and distributional characteristics - these FWs can also be incorporated in infants' *syntactic* and *semantic* analyses of phrases and sentences.

The current work thus demonstrates that the process in which FWs become an integral part of the child's computation and representation of language occurs already during an early stage in the acquisition of language (at least with certain FWs such as the determiner '*the*'). It is therefore plausible that the transition from differentiating FWs based on their sound structure and distributional characteristics to distinguishing their *grammatical* function in sentences begins (at least) by children's first birthday, much earlier than previously thought (e.g., Bowerman, 1973; Halle *et al*., submitted; Radford, 1997; Schlesinger, 1981).

7.1.5. *A Strong Function Word Effect*

It is important to note that the overall effects in accuracy (*First Look*) and speed of looking (*Latency*), which are reported in this dissertation, have been obtained despite the fact that across all test conditions the target noun was always heard and its representative image was always seen. Thus, the task of identifying the target image was relatively easy regardless of the grammaticality of the sentence or the particular function word which was featured in it (i.e., '*the*'; '*and*'; '*el*'; '*null*').

Second, the auditory stimuli which were used in the current studies were digitally edited and carefully controlled to avoid a confounding effect of prosody and phonology (i.e., to avoid a situation in which subtle prosodic and/or phonological characteristics of the test sentences serve as cues for the infants on the task). Thus, the infants who were tested on the current design could only consult the *grammatical* occurrence of a specific [*FW* + *Noun*] combination as a possible cue for differentiating the four sentence types.

Third, note that even when '*the*' was omitted or substituted, the basic syntactic structure of each of the sentences did not vary. That is, all of the test sentences followed a *Subject-Verb-Object* (SVO) sentential structure. Nonetheless, although the 12-, 18- and 24-month-old infants could presumably process the manipulation of a single FW as only a trivial change in the sentence's overall structure and meaning, the current results show that this manipulation was by no means insignificant for the infants in processing the linguistic input and in visually determining the noun reference. Therefore, these findings suggest that the role which FWs play in infants' representation and computation of language cannot be underestimated.

Lastly, the current task was also designed with sequential presentation of the auditory and visual stimuli. This procedure allowed the infants to focus on the auditory input first, without the images distracting them. The results demonstrated that although there was a brief pause following the presentation of the test sentence and prior to the presentation of the images, infants would still orient faster and more accurately to the target image following the grammatical condition (‘*the*’). That is, the effect of the FW manipulation was apparently strong enough to be extended beyond the infants’ on-line processing of the auditory and visual input.

7.2. *Broader Implications*

The current findings shed light on several other issues in the study of language acquisition, and more generally on the role of FCs in language, as was discussed in *Chapter 2*. This section thus addresses some of the broader implications to which the current findings relate.

7.2.1. *Distinguishing Count and Mass Nouns*

What can we learn from the comparison between the grammatical condition (‘*the*’) versus the ‘*null*’ condition in the current research program? How does it compare with cases in which the exact same contrast was run in previous studies (e.g., Gerken & McIntosh, 1993; Zangl & Fernald, 2003)? Note that in order to distinguish the grammatical and the ‘*null*’ conditions in the current design; some awareness regarding the phrase structure requirements in English for count versus mass nouns seems essential. That is, the infants may have been aware on some level that a determiner (or perhaps more generally, some type of FW) is required to head the noun phrase for singular count nouns such as those that were used in the current design (e.g., ‘*Give me the book*’; ‘*I have a dog*’) - but not necessarily for mass nouns (‘*I am drinking water*’).

Interestingly, there appears to be no consistent pattern of results stemming from this specific contrast across the above studies - in which different age groups were tested and different methods and measures were employed. Specifically, while some measures (i.e., *Pointing to Target* - Gerken & McIntosh, 1993; *First Look to Target* – this dissertation; *Proportion of Looking Time* – this dissertation and Zangl & Fernald, 2003) – have failed to find a difference in infants' response to these two conditions, other measures did in fact yield significant differences, as early as 18 months of age (see *Experiment 1*; *Latency*).

Gerken and McIntosh (1993) hypothesized that the 2-year-old children in their study may have not distinguished the grammatical condition and the '*null*' condition because they do not yet reliably distinguish between English count and mass nouns. However, that must not necessarily be the case. As the latency results in *Experiment 1* have shown, the 18- and 24-month-old infants' orientations to target following grammatical sentences were significantly shorter than those following '*null*' sentences. In addition, in *Experiment 3*, the 12-month-old infants also seemed to have treated the '*null*' condition differently from '*the*' (see *First Look*; *Latency*), although this contrast did not reach significance (see *Figure 4*).

These findings suggest that some of the early foundations for the distinction between English count and mass nouns may begin to develop between 12 and 18 months of age. However, this early sensitivity surely does not indicate a solid grasp of the complex semantic and syntactic factors that are involved in forming the full-fledged mass/count distinction. Such sensitivity has been shown to appear and develop only in much later stages of language acquisition (e.g., Gordon, 1988; Barner & Snedeker, 2005).

Instead, the current findings regarding the distinction between '*the*' versus '*null*' conditions more likely stem from infants having a general expectation for a FW to precede a noun (i.e., *the book*, *a dog*) based on the transitional probability of such co-occurrences in their linguistic input. That is, English-learning infants hear more

[*Determiner + Noun*] co-occurrences in comparison to cases in which a noun appears without an accompanying FW. Further investigation focusing more closely and more directly on infants' developing awareness of the count/mass distinction in English is needed now. Such exploration could better our understanding of the infants' performance in the current studies.

7.2.2. *Early Sensitivity to Phrasal and Sentential Contexts*

The present findings indicate that the 12-, 18- and 24-month-old infants must have processed the broader syntactic sentential context in which the function-content word combinations appeared (i.e., a FW followed by a noun).

As suggested above, the infants must have attended to the entire syntactic structure of the sentence rather than only the noun (or *Noun Phrase*) at the sentence's end. In fact, although infants could have simply ignored the pre-nominal FW (i.e., '*the*', '*and*' or '*el*') and instead locate the visual target by attending only to the noun at the end of each sentence – the current results suggest that this was not the case (i.e., infants were also processing the FW which preceded the noun). Such evidence strengthens recent views (e.g., Aslin, Woodward, La Mendola, & Bever, 1996; Fernald & Hurtado, 2006), according to which children's early processing of language is facilitated – much like adults – when function and content words are structurally combined (i.e., at the phrasal and sentential levels), rather than on a telegraphic, single-word basis as other researchers have claimed (e.g., Brent & Siskind, 2001; Peters, 1983).

Interestingly, the infants' performance in the familiarization stage and the following task in *Experiment 3* may be a good example for how both function and content words interact in sentence processing at the early stages of language acquisition. Thus, the 12-month-old infants could have first formed a word-object association based solely on lexical labels (e.g., '*book*'; *familiarization* stage). However, during the actual test trials, being familiar with the label for each object seemed insufficient for infants in order to perform successfully on the task. Instead, infants also consulted the grammatical information associated with the specific FWs that appeared in the test sentences as well as with the overall structure of these sentences.

7.2.3. *The Syntactic Bootstrapping Hypothesis*

The current findings appear consistent with the *Syntactic Bootstrapping* hypothesis. This hypothesis emphasizes the role of syntactic structure in facilitating and guiding the acquisition of language, including vocabulary, already during children's first two years of life (Fisher, Gleitman & Gleitman, 1991; Gleitman, 1990; Landau & Gleitman, 1985). The new findings which are reported in this dissertation and which demonstrate early grammatical sensitivity to FWs in the computation of sentences seem to converge with previous studies in which young children have been shown to make use of other types of syntactic knowledge in processing language.

Thus, the child's incorporation of FWs in the syntactic analysis of sentences is part of a broader syntactic representation which includes additional elements of syntax, for example, word order, inflection, verb transitiveness and agreement (e.g., Fisher, 2002; Hirsh-Pasek, Golinkoff, & Naigles, 1996; Naigles, Gleitman & Gleitman, 1993; Soderstrom, Wexler, & Jusczyk, 2002).

7.2.4. *Knowledge versus Ability in the Domain of Language*

It is often the case where researchers are considering children's productive speech as a direct measure and an accurate representation of their linguistic competence. However, it has been shown that language production can dramatically differ from language processing and language comprehension as a basis for inference regarding children's actual linguistic (and cognitive) competence (e.g., Chomsky, 1980, 1986; Hirsh-Pasek, *et al*., 1996; Lust, 2006; Lust, Chien & Flynn, 1987; Pinker, 1994).

In the current work, infants of 12- to 24 months appeared to be sensitive to the FW-manipulation across the four types of sentences despite the fact that none of these infants actually produced FWs in a correct or consistent manner, if at all. This finding provides further evidence that children's linguistic competence may exceed what they are able to articulate. How can such gaps between what the child knows versus what they are able to express overtly be explained? What brings about this incongruence between the child's receptive and expressive skills?

Specifically in regards to the main research question discussed in this dissertation, we must ask why young children tend to omit FWs in their early productive speech (in some languages, such as English)[25]. According to Gerken and her colleagues (as well as other researchers), the main reason for children's omission of these words results from limitations in speech planning and production which are phonological in nature, rather than lack of syntactic or morphological knowledge (e.g., Boyle & Gerken, 1997; Demuth, 1992; Gerken, 1994, 1996; Gerken & McIntosh, 1993; Gerken *et al*., 1990; Pye, 1983).

In particular, it has been suggested that early omissions of FWs result from children's initial reliance in their productive speech on a metrical production template, in which a strong syllable is followed by an optional weak syllable (i.e., a trochaic foot). Children supposedly implement this strong-weak template by "*aligning the strong syllable of each template with a strong syllable of the intended utterances*"

[25] However, as discussed in *Chapter 4*, Carter & Gerken (2004) have shown that 2-year-old infants show 'whisper-like' traces when attempting to produce weak, unstressed syllables in English FWs. Thus, infants who are acquiring English do consider FWs even when they omit them in production.

(Boyle & Gerken, 1997). Thus, while children are consistent in producing weak syllables that belong to a strong-weak, trochaic foot, they frequently omit weak syllables that do not belong to such a foot.

In sum, young children (0-3 years) may often struggle with the production of FWs. However, this difficulty in producing FWs occurs for reasons that are non-syntactic but rather motorical/phonological in essence. Thus, these children are in a much more advanced stage in terms of their awareness of FWs and in their ability to incorporate these grammatical elements in the syntactic representation and online computation of sentences.

7.2.5. *Infant Methodologies - Experimental Insights*

The current design and results touch on some general methodological issues concerning infant research. In general, these findings demonstrate that different outcomes are possible both within the same method as well as across different methods based on the exact nature of the task and how precisely the infants' behavior is measured.

First, as discussed above, experimental designs that have focused on natural productive speech data in children's acquisition of language (typically focusing on child utterances in English, but not in other languages) - have often failed to detect the child's full linguistic competence in a particular domain of language. This also applies directly to discovering the role of FWs and FCs in language acquisition. Thus, researchers have often explored only when and which FWs children produce (in English), but have typically neglected to investigate children's competence in (covertly) processing functional elements in language.

Second, comparing the current studies to Gerken and McIntosh's (1993) study, makes clear that the use of different measures had a crucial effect in both replicating and extending their results. Interestingly, the dichotomous (i.e., *Correct*/*Incorrect*), *First Look* measure has yielded identical results to Gerken and McIntosh's (1993) picture-pointing measure. Specifically, in both studies, the use of such binary measure was sufficient to capture infants' differentiated response towards the grammatical condition versus the two ungrammatical substitution conditions (i.e., English FW: '*and*' - '*was*'; Nonsense FW: '*el*' - '*gub*'). This resemblance in results between the *First Look* measure and Gerken and McIntosh's pointing measure may also have arisen because these two measures are similar in that they only examine the child's first (immediate) reaction to the stimuli (albeit in different modalities, i.e., *motor/pointing* vs. *perceptual/looking*).

Notice however that *Latency to Target*, which is also based on infants' immediate response to the stimuli - is a continuous, time-sensitive measure. The *Latency* measure crucially differs in this respect from the dichotomous measures mentioned above. This difference became clear in the statistical analyses. Specifically, the *Latency* measure appeared highly valuable for these studies' purposes since it enabled the extension of Gerken and McIntosh's (1993) results to two younger age groups (12- and 18-month-olds); and in addition yielded a significant difference between infants' response to the grammatical condition versus the '*null*' condition in which the FW had been omitted.

Moreover, the current studies have shown that different results may be found even within the same method, where only certain measures may capture the full scope of the child's linguistic competence. For example, different from the *Latency* and *First Look* measures which focused on infants' *immediate* response to the images; *Proportion of Looking Time* was based on infants' looking behavior for the duration of the entire test trial (Six seconds in *Experiment 1* and in *Experiment 2*; Four seconds in *Experiment 3*).

Thus, although the infants initially might have been distracted by the syntactic anomaly in the sentence, and consequently shifted their gaze between target and distractor - they would still have had sufficient time to fixate at the target image for the rest of the trial and hence compensate for the effect of the ungrammatical condition. For this reason, the PLT measure, which has typically been extremely useful in preferential-looking research with infants - did not yield significant differences across the different conditions, in any of the three age groups tested in this research program.

In sum, the experiments in this research program demonstrate that caution must be taken when choosing and applying experimental designs to study language and cognitive development in infancy. Specifically, the results imply that early linguistic sensitivities may not be traceable by a particular method or measure, but are nevertheless present in the young child.

7.3. *Open Questions and Future Directions*

In this dissertation I have argued that the different looking patterns, which the 12- to 24-month-old infants demonstrated following the grammatical versus the ungrammatical sentences, must have reflected an integration of early phonological, prosodic, distributional sensitivities as well as certain syntactic awareness regarding English FWs. According to this view, the (apparent) transition from initially detecting FWs based on their sound structure, prosody, frequency, and distributional characteristics - to begin accessing some of their *syntactic* properties - occurs by children's first birthday (this ability may be present even at earlier stages).

More broadly, I have argued that the 12-, 18-, and 24-month-old infants who were tested in these studies, were consulting some of the grammatical information which is tied to certain FCs such as *Determiners* and *Complementizers* (rather than ‘only’ to specific FWs) as they were processing the test sentences. This implies that (some) FCs are grammatically functional for infants, and are carrying an important role in guiding infants’ online computation of sentences already during early stages in young children’s acquisition of language.

7.4. ***Easy Problems, Hard Problems***

The above conclusions must take into account several questions which remain open regarding the current design and findings, as well as some broader issues in the study of the acquisition and mental representation of FCs. The next sections introduce these open issues and suggest ways for testing them empirically. To borrow Chalmers’ (1992) conceptual divide between ‘*Easy Problems*’ versus ‘*Hard Problems*’ in the study of *consciousness* - let us now follow and classify the next questions regarding the status of FCs in early language acquisition as ‘*Easy*’ or ‘*Hard*’.

7.4.1. *The ‘Easy’ Problems Regarding the Acquisition of Functional Categories*

The ‘*Easy Problems*’ would generally concern further experimentation and cross-linguistic comparisons in order to generalize and validate the developmental literature (including the current findings) on children’s early grammatical access to FWs and FCs. First, specifically regarding the current findings, we must ask whether the distinct looking responses across the test conditions which the 12-, 18- and 24-month-old infants demonstrated (in particular, in comparing the grammatical sentences versus the ungrammatical sentences which have used ‘*and*’ as the FW) - were actually based on a linguistic analysis that involved a *syntactic* component.

Alternatively, other aspects of the linguistic input, such as its phonological or distributional patterns, could perhaps be sufficient for the infants to distinguish the grammatical and ungrammatical sentences. Second, we must define the scope and extent to which such early syntactic sensitivity applies. For example, are infants sensitive to the full range of FCs in a given language, or are certain FCs accessed earlier than others?

The next sections introduce several ways in which previous findings, and more specifically, the findings in this dissertation, could be replicated using a variety of measures and methodologies; and extended to additional age groups, different types of FCs, other languages, and different sentence templates, among others.

As discussed above, the ultimate purpose of these proposed studies is to generalize and validate the main argument which I have advocated in this dissertation, according to which the 12- to 24-month-old infants who were tested on the current preferential-looking design did not only detect FWs in the speech stream, but also consulted FWs for –

(i) The syntactic processing of sentences;

(ii) Deriving some aspects of sentence meaning; and

(iii) Establishing noun reference in different sentential contexts.

Furthermore, such proposed studies would be beneficial for pinpointing the developmental timeline in which such early grammatical sensitivity to FCs becomes apparent in the child.

7.4.1.1 *Early Grammatical Access to Function Words?*

I have presented several arguments in favor of the claim that the current findings do in fact demonstrate infants' *syntactic* processing of the test sentences and the specific English FWs that constructed them. First, distributional productivity alone does not seem to fully account for the distinction between the sentences using '*and*' versus '*the*', given that '*and*' is also highly frequent in English. Second, since '*and*' may and does precede a noun in English (i.e., '*and*' may take a noun complement in English) - then if local distribution patterns were the dominant factor contributing to the infants' distinction between '*the*' and '*and*', we would expect '*and*' to be also differentiated from the other ungrammatical FW ('*el*'). However, the infants treated all three ungrammatical conditions similarly. Third, the interrogative sentence structure that was used in the current design maintains a grammatical structure until the noun is heard. Consequently, infants had to compute the entire syntactic structure of the sentence in order to distinguish these two critical conditions, '*the*' versus '*and*'.

7.4.1.2. *Validating the Current Results*

Further studies are now needed in order to verify and better understand infants' incorporation of FWs in sentence processing. For example, one useful test would be running a reverse condition to the '*The*' versus '*And*' contrast in the current design. That is, presenting infants with test sentences in which '*and*' serves as the grammatical FW - whereas '*the*' does not fit in grammatically. If infants distinguish these conditions it will demonstrate that the grammaticality of the FW in a given context is superior to its frequency and co-occurrence patterns in English. Although '*the*' is more frequent than '*and*' in English, and although ['*the*' + *Noun*] combinations are more common than ['*and*' + *Noun*] combinations – infants may still base their computation of the sentences on the grammatical role of '*and*' and '*the*' rather than the distributional co-occurrence patterns of these FWs. Additional manipulations also seem necessary in order to generalize other aspects of the current design. For example, alternating the position in which the grammatical and ungrammatical FWs appear (i.e., beginning/middle/end of the sentence); manipulating more than one FW in a sentence (e.g., '*if dog chased to cat*' versus '*the dog chased the cat*'); or introducing additional templates for the test sentences – for instance, not only questions (e.g., '*can you see…?*') but imperative and declarative sentences as well (e.g., '*give me and ball*').

7.4.1.3. *Early Sensitivity to Function Words or to Functional Categories?*

Let us consider the answer to the previous question positive for now. That is, that the infants' performance on the present task was indeed a reflection of their access to the different grammatical roles of '*the*' versus '*and*' in English. However, we must ask whether this was a special case which was based on the specific pair of English FWs that were chosen in the current design. I now address several non-syntactic factors, that is, distributional, phonological and semantic-pragmatic aspects of infants' linguistic input, which may have played a role in guiding infants on the current task. Such intervening factors may have made infants' distinction between sentences using '*the*' versus '*and*' possible, but perhaps would not sufficiently account for a broader, across-the-board syntactic sensitivity by infants to a whole set of different FWs and FCs.

The Frequency Factor. As mentioned above, both '*the*' and '*and*' are highly frequent in English. Studies of word recognition have shown that high-frequency FWs are becoming part of the child's receptive lexicon earlier than less-frequent FWs. For example, Shi *et al*. (2006a) report that the pronoun '*her*' - which is less frequent in English than the determiner '*the*' - was not recognized as easily by 11-month-old, English-learning infants. Such bias towards higher-frequency words in acquisition may well also be the case in infants' incorporation of FWs in the *syntactic* analysis of sentences - with more frequent FWs becoming grammatically functional earlier than less-frequent ones. Thus, distributional and syntactic effects work in tandem in forming the child's grammar. For example, Höhle *et al*. (2004) claimed that their main result – that is, 14 to 16-month-old infants' ability to classify a novel word as a noun based on a [*Determiner* + *Noun*] pairing preceding it, but their failure to similarly use a [*Pronoun* + *Verb*] pairing to classify a novel word as a verb – closely reflect the linguistic input these infants had received, that is, determiners being more frequent in German than pronouns[26].

Matching the Function Word 'Prototype'. Factors other than word-frequency may also influence infants' developing syntactic competence regarding FWs. One such factor relates to the fact that some FWs (e.g., '*at*', '*and*') associate more closely with the general phonetic and prosodic FW prototype (e.g., monosyllabic, unstressed) than others (e.g., '*between*', '*therefore*'). Such 'representative' FWs may be better candidates to be incorporated in infants' early grammatical processing of language. Furthermore, the process of distinguishing FWs (and content words) – that is, from under-specification to detailed phonetic encoding - is far from being complete by 12 months. English-learning infants have been argued to fully capture FWs in phonetic detail only around 10.5 to 11 months of age (e.g., Shi *et al*., 2006a,b; Shafer *et al*., 1998; Werker & Yeung, 2005). It is therefore possible that the FWs that were selected for this study are already phonetically well-established at 12 months, whereas other FWs would not yet be an integral part of the child's vocabulary and hence would play no part in grammatical computations.

Semantic Load. Some FWs seem to be conveying more meaning than others – for example, '*under*' versus '*at*'. As mentioned above, several researchers have argued that the semantic information which is carried by a word in a specific context (rather than the Content/Function distinction) may in fact be a more accurate account of how

[26] Based on Höhle et al.'s (2004) analysis of child-directed speech in German.

the lexicon is organized in the mind (Bird, *et al*., 2002; Friederici, *et al*., 2000a,b; Kutas, 1997). Thus, it is possible that the two specific English FWs that were selected for this study belong to the less 'semantically-loaded' group of FWs; and that such words may be easier for infants to incorporate into syntactic analyses of sentences.

To summarize, the task of learning FWs may follow a similar path to learning content words, where more frequent and/or accessible words (e.g., '*dog*') are typically acquired and processed earlier than less-frequent (and less-concrete) words (e.g., '*wisdom*'). In addition, FWs which are highly-frequent and simple-structured (e.g., '*the*', '*a*', '*and*') may be more accessible for the child for both phonological encoding and syntactic incorporation in comparison to FWs which do not adhere to these characteristics (e.g., '*although*', '*under*'). In order to test these proposals, future studies must test infants' access to a variety of other FWs - including ones that are not as common in the language - to see whether and at what developmental stage such words appear to be incorporated in children's syntactic analyses of sentences.

Moreover, it is important to note that the current set of studies - as well as Gerken and McIntosh's (1993) study – contrasted only one exemplar from each FC. That is, a determiner ('*the*') versus a conjunction ('*and*') [27]. Thus, future studies should also test whether infants can categorize different FWs in accordance with the different types of *Functional Categories* they belong to, for example, contrasting a *set* of *Determiners* ['*a*', '*the*', '*some*'] versus a *set* of *Conjunctions* ['*and*', '*but*', '*or*']. As discussed above, such comparisons were in fact tested by Höhle *et al*. (2004)[28] who have found that 14-month-old infants accessed an entire set of German Determiners

[27] However, as discussed above, Gerken and McIntosh's (1993) study contrasted '*the*' with the auxiliary verb '*was*'. Hence, the current study along with Gerken and McIntosh's study in fact point to infants' recognition of three distinct FCs: CP - 'and'; DP - '*the*'; and IP - '*was*'.

[28] See also Mintz (2006) and Peterson-Hicks (2006) for similar studies with English-learning infants.

for the syntactic computation of sentences, hence providing first evidence for such early lexical categorization of FWs. However, Höhle *et al*.'s analysis failed to show similar categorization for German pronouns[29], which again raises the question of whether specific FWs, or more broadly, specific categories of FWs (i.e., FCs), may be accessed more easily and earlier than others, hence forming a *hierarchy* for the acquisition of FCs.

7.4.1.4. *Cross-Linguistic Research*

Obviously, such possible hierarchies in the order in which FCs are acquired could also be a function of the substantial variation in the types and roles of different FWs and FCs across languages (see Kayne, 2005; Lust, 2006). For example, as discussed above, several languages – in contrast to English - seem to lack completely or use only a limited set of *Determiners* (e.g., Cantonese; Russian; Serbo-Croatian). For this reason, cross-linguistic comparisons of infants' grammatical access to FWs seem crucial in order to distinguish universal versus language-specific early knowledge regarding FCs.

7.4.2. *The 'Hard' Problems Regarding the Acquisition of Functional Categories*

Validating the above conclusions in a comprehensive and detailed manner - that is, confirming that FWs are indeed grammatically functional by 12 months of age, and providing a detailed account of which types of FCs seem to be processed grammatically by infants across languages and at what developmental stages - would lead us toward a new frontier in studying the acquisition of FCs in particular and of language in general, in which two fundamental ('*hard*') questions seem especially important.

[29] In fact, the status of pronouns, that is, whether they should be considered FWs – is debated.

7.4.2.1. *Understanding the Mechanism*

The first question is what *mechanism* (or, *developmental process*) may explain infants' access to the grammatical role of FWs by 12 months? Specifically, we must ask what may account for the main result presented here, that is, the child's very early awareness that the syntax of the *Determiner Phrase* in a sentence, and the reference of the noun embedded in it, are linked.

If infants of 12 months of age truly possess grammatical sensitivities to the role of FWs and FCs in language, how are these sensitivities related to other types of linguistic competence which have been shown to be present around the 1-year marker (e.g., phonological, prosodic, distributional and semantic sensitivities)? How does such sensitivity develop in the child? Do children discover the grammatical role of FWs based on a word-by-word learning process; or do they alternatively consult some *a priory* (innate) categorical information regarding the organization of language and the role of FCs in constructing the syntactic skeleton of sentences?

As mentioned above, previous research (e.g., Höhle & Weissenborn, 2003; Shady, 1996; Shafer *et al*., 1998) implies that infants become sensitive to the purely distributional uses (without reference) of functional elements in the speech stream already during the first year. The current findings demonstrate that around children's first birthday, different FWs are distinguished based their syntactic properties in the specific language the child is acquiring.

We can now ask what is the process of development that occurs before 12 months of age in the acquisition of FCs? Importantly, even if the initial mechanism is distributional (e.g., noticing that in English '*the*' occurs at the beginning of noun phrases) - the child still has to eventually figure out when to use a specific FW based on its *grammatical* role (e.g., '*the*' as a FW which specifies *definiteness* and *argumenthood*). Moreover, it is important to mention that unlike many content words, children rarely get a direct explanation or reference from adults about the meaning and role of FWs in their language. However, FWs do carry some meaning - they convey certain relations between content words that the child learns eventually. How then does the child learn the relational and structural meanings that FWs help to convey in sentences?

Finally, the basic developmental question remains: How are FCs incorporated in the child's language? Why does a child seem to know something about FCs in age X but not in age X - 1 day, week or month?[30] Is some knowledge regarding FCs present from the earliest stages of language acquisition? Most if not all of the theoretical views which I presented in *Chapter 3* regarding the acquisition of FCs, would agree that a child at birth cannot possibly know everything about how and which FCs are used in her own particular language. However, different explanations are given to the process by which the child eventually reaches the 'final-state' in which she knows which and how functional elements work in their language.

7.4.2.1.1. *A Blow to Maturation Theories?*

The present findings seem to critically challenge the maturational view on language acquisition, in particular regarding the acquisition of FCs. Thus, if already around one year of age infants are accessing the functional lexicon when processing sentences; and if they perform this computation based on access to the functional word category of *Determiners* – then the hypothesis that the child lacks any representation of FCs during the first two or three years of life would be disconfirmed[31].

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[30] Obviously, given the variability among individual children, the exact age is not as important as the broader developmental stage the child is in, and the order or sequence according to which FCs are incorporated in children's syntactic processing of sentences.
[31] Alternatively, the maturation of FCs occurs already during the first few months of life.

In this case, two main hypotheses which were described above seem to remain open for investigation – the UG-based *Continuity Hypothesis* versus the general learning/cognitive approach. For researchers relying on the UG framework, the challenge would be to explain how children would know how to label specific words which they hear as either FWs or content words; how they would map words into the right syntactic category (e.g., '*the*'→DET→FCs; '*book*'→Noun→Content Category); and finally, how they would match strings of words to the principles of grammar which they presumably already possess (i.e., into phrase structure constituents).

For learning/cognitive theorists, the major challenge would be to explain how the child can advance from detecting certain reoccurring combinations of FWs with content words in the speech stream, to constructing the necessary abstract knowledge of classifying each word into the syntactic category it belongs to and of recognizing the specific constructions in which it may appear.

7.4.2.2. *The Nature of Early Grammatical Processing of Function Words*

A second fundamental issue is to define in more detail which grammatical aspects of FCs (in particular, *Determiners*) are in fact accessible to infants: That is, what *precisely* did the infants detect regarding the determiner '*the*' at 12, 18 and 24 months of age? What syntactic properties of this article, as well as other FWs, do infants access in the early stages of language acquisition? How does infants' representation of a particular FW, or FC, change over time to eventually match the adult's point of view?

If the infants were indeed attending to the grammatical role of '*the*' versus '*and*' in computing the test sentences - were they accessing the (functional) word *category* of *Determiners*; or were they perhaps only familiar with the grammatical role of these two specific FWs in English sentences?

Further research should thus aim at identifying the *nature* as well as the developmental course (both before and after the age of 12 months) of this advancement in infants' apparent linguistic competence. That is, we must try to pinpoint the developmental process in which FCs and FWs become grammatically functional for the child. At the same time, we should also follow up on this new sensitivity to see if and how it may change over time (e.g., what additional knowledge regarding FCs might the 24-month-olds in *Experiment 1* have had in comparison to the 12-month-olds in *Experiment 3*?).

These questions seem crucial since it has been shown that the child's comprehension of the full pragmatic and semantic aspects of the functional lexicon takes years to fully develop (Lust, 2006). For example, children may learn to distinguish definite and indefinite determiners such as '*the*' and '*a*' only at relatively late stages in development (e.g., Foley, Lust, Battin, Koehne & White, 2000; Schaffer & Matthewson, 2005). According to Friederici (1983), full sensitivity and understanding of closed-class FWs may develop at late stages in development, in fact, only around the age of 10 years, in comparison to content words.

Given this gradual growth in the child's representation and understanding of FCs in general and of *Determiners* in particular – yet without accepting the notion of a pre-determined maturational master plan for FCs (e.g., Radford, 1997) – the (*Continuity*-driven) *Grammatical Mapping Hypothesis* seems to be a strong candidate for explaining the current findings (e.g., Boser *et al.*, 1992; Lust, 1999, 2006; Santelmann, *et al*., 2002). Thus, although children may be fully equipped at birth with all UG-related principles, including those which relate to FCs and their role in language, the child must still integrate these universal principles to the specific language grammar with which she is dealing (e.g., Lust, 1999, 2006).

We must now explore what exactly is the *partial* awareness of FWs, in particular, *Determiners* - which seems to be in place at the early ages of 12, 18 and 24 months; and to what degree is the child's detection of *Determiners* linked to their syntactic and semantic awareness of sentence phrase structure architecture, and how? These questions seem as the major challenge in our investigation of the acquisition of FCs in general, and of DP constructions, in particular.

7.4.2.3. *The Next Step - Neurolinguistic Research*

The next developmental inquiries should go beyond showing that children have some grammatical awareness of the role of certain FWs in sentences. We should now attempt to find out *how* they acquire this knowledge (i.e., in a bottom-up or top-down manner); whether some FCs are acquired before others (and why); and when and how does the mapping in the child's mind between the morphology and syntax of FCs (i.e., *Specific FWs* ←→ *General FCs*) occur.

One promising empirical approach for tackling these questions would be to conduct developmental neurolinguistic studies in which the child's brain activity following a linguistic stimulus is measured. In particular, the ERP method seems valuable because it can be applied to infants relatively easily. Moreover, because the evoked brain responses are time-locked to the linguistic stimuli, the ERP technique may be more accurate in exploring infants' *on-line* sentence processing rather than measures such as pointing, head-turning and looking which are typically used in behavioral studies.

Importantly, the findings from previous ERP studies (with adult subjects) have confirmed that different brain activity signatures appear in language processing tasks, each of which represents a specific type (e.g., phonological, semantic, syntactic) of online linguistic processing (e.g., Friederici, *et al*., 2000a; Hagoort, Brown, & Osterhout, 1999).

Only a few neurolinguistic studies have explored so far whether children and infants would also demonstrate such relatively fixed brain response patterns (e.g., Hahne, Eckstein, & Friederici, 2004; Shafer *et al*., 1998)[32]. If such distinct signatures would in fact be verified in the child, then ERP studies could prove to be extremely valuable in identifying the exact type of mechanism that guides infants in distinguishing grammatical and ungrammatical sentences such as those that were used in the current design.

7.5. *Conclusions*

The findings presented in this dissertation provide further evidence for the crucial role of functional word categories in human language. Specifically, this work provides new empirical evidence for the hypothesis that FCs, which are realized in language by a set of FWs, may serve as primary cues for the child during the early stages of language acquisition (i.e., the first two to three years of life). It is thus suggested that FCs play a vital role in young children's mastery of syntax and semantics, in particular, by facilitating and guiding early word learning, word categorization and sentence computation.

In general, this dissertation converges with several behavioral and neuroscience studies with adults, children and special populations (e.g., aphasics) which have shown that the main FCs (e.g., CP, DP, IP) are (cross-linguistically) treated differently than content categories, and appear to be available to the child even

[32] However, even when linguistic tasks produce different ERP components, it is not always clear what these components are indexing. For example, the N400 and P600 are not necessarily specific to language processing since they engage resources related to memory, attention, and other cognitive functions.

during earliest stages of language acquisition. Functional categories seem to provide a skeletal structure which children build on in order to learn the grammar of the specific language they are acquiring. As discussed earlier, the basic set of FCs seems to arise instantly in the child's representation and use of language, even in the most extreme social circumstances in which no (or only a limited) language model is provided, such as the cases of pidgins transforming to creoles, or the cases of deaf children which have invented their own sign language.

Specifically, these results suggest that the 12-, 18- and 24-month-old infants were familiar with certain syntactic properties of the English FWs '*the*' and '*and*'. That is, the infants consulted these FWs as they were processing the test sentences and looking for their visual referents. Although this sensitivity must involve the frequent distributional co-occurrence patterns of FWs and content words in English - in particular, the co-occurrence patterns of determiners and nouns – I have presented several arguments to suggest that infants must have also consulted the *syntactic* context in which the combinations of function and content words occurred. Particularly, the infants must have distinguished combinations of ['*and*' + *Noun*] and differentiated this from the combinations of ['*the'* + *Noun*]. Lastly, these results demonstrate that phrasal structures which combine FWs and content words ('*the ball*') have priority over simple lexical items ('*ball*') for linking to semantics and determining reference, already at these early stages in the acquisition of language.

7.5.1. *Final Remarks*

To conclude, I return to the main questions presented in this chapter, namely:

(i) What constitutes infants' early grammatical sensitivity to functional elements in language, as documented in this dissertation? When and how are FCs represented in the child's mind?

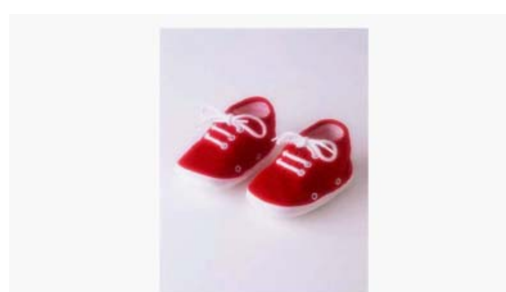
(ii) What linguistic and/or cognitive mechanisms can build up such early sensitivity, that is, already by 12 months of age?

(iii) Which mechanisms continue to guide the child's expanding knowledge regarding the functional lexicon in their language? (e.g., what drives children's realization of the complex syntactic and semantic aspects of the definite/indefinite distinction in language?)

The current experimental work with 12-, 18- and 24-month-old infants has demonstrated that by examining in detail young children's perception and processing of spoken language (in this case, English) - new and exciting findings about what is available to the young child regarding FCs may become apparent. Further (cross-linguistic) research with infants and children should now aim at defining more precisely the nature of this early grammatical access to functional word categories, as well as identifying and understanding the developmental mechanisms which first trigger and then broaden this syntactic sensitivity to FWs and FCs throughout the child's first years of life.

By carefully designing such studies in which we pursue the child's covert linguistic competence in regards to the grammatical function of FCs in language, as well as other syntactic and semantic aspects of language - rather than focusing only on children's expressive language - we may find ourselves surprised by how fast and how far the young child advances in accomplishing the seemingly impossible task of acquiring a first language.

APPENDIX

CUP 	PHONE 
BED 	HAT 
PLANE 	TRUCK 
CAR 	SHOE 

BALL 	BOOK 
BIRD 	DOG 
BRUSH 	SPOON 
DUCK 	CAT 

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