汉语幼儿功能语素启动下的语法范畴习得

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Mandarin-Speaking Toddlers' Acquisition of Grammatical Categories with Functional Morphemes

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摘 要

语法范畴化是儿童语言习得一个关键的环节。为了获得语法，儿童需要把连续语流中听到的单词分类为抽象的语法类别，例如名词和动词。先前的研究表明，婴儿由于功能语素的声学和分布特性，早期已开始存储功能语素，并使用它们来识别切分短语，根据其共现规律对相邻词进行语法范畴的归类。

本研究使用注视法，测试 19 个月大的汉语幼儿是否可以利用常见的句中功能语素来分析不熟悉的词串。在实验中，被试首先在熟悉阶段随机熟悉了一组 XaY 的三词序列，其中功能语素 a 始终不变，可以是体标记后缀“了”（将 X 归为动词）或否定词“不”（将 X 归为名词），而单音节目标词 X 和双音节填充词 Y 是在变化更替的生词。接着，他们在测试阶段听到目标词 X 交替出现在一组名词语境（‘是这个 X_N’）及一组动词语境（‘都可以 X_V’），用于测试他们是否区分两组合法性不同的句子（与熟悉阶段 X 的词性相同即合法，反之则不合法）。后续实验采用相同的设计，功能语素被换成了焦点标记“也”。儿童如果能使用熟悉阶段的句中功能语素对前置目标词 X 进行范畴化，预期结果则为能够区分两组测试句。结果表明，幼儿在“了”和“也”的条件下成功对前置目标词的语法范畴进行了归类，而在“不”的条件下并没有成功。

本研究表明，汉语幼儿可以通过目标词后接的功能语素对目标词进行逆向的语法范畴归类。此外，幼儿未能用否定词“不”将前置目标词归类于名词表明，儿童倾向于对功能语素所在短语内的词进行语法范畴化。我们的发现也进一步揭示了儿童拥有丰富的功能成分表征，能将其用于组织短语及句子结构，启动语法范畴习得。

关键词：语法范畴化；语言习得；功能语素；注视法；汉语

Abstract

Grammatical categorization is a crucial part of child language acquisition. To acquire syntax, children need to classify words they hear in the continuous stream of speech into abstract grammatical categories such as nouns and verbs. Previous studies show that infants store functional morphemes or functors early in life due to their acoustic and distributional properties and use them to identify phrases and categorize adjacent words based on their co-occurrence patterns.

Using a Visual Fixation Procedure, we examined whether Mandarin-learning 19-month-olds use common utterance-medial functors for parsing unfamiliar word clusters. In the experiment, toddlers were randomly familiarized with 3-word sequences like *XaY*, where the invariable functor *a* was either the aspectual suffix *-le* (categorizing *X* as a verb) or the negation marker *bu* (categorizing *X* as a noun), while the varying monosyllabic target words *X* and disyllabic filler words *Y* were unknown to toddlers. They were tested on their distinction of alternating trials presenting the target words *X* in new noun contexts (*shi zhege* X_N 'be this-CL X_N') or verb contexts (*dou keyi* X_V 'all may X_V') that were either grammatical or ungrammatical depending on the syntactic category of *X* during familiarization. In a follow-up study, toddlers were familiarized with the focus particle *ye* as the utterance-medial functor using the same design. Toddlers were expected to discriminate between the two types of trials if they had categorized *X* preceding the functor during familiarization.

The results show that toddlers succeeded in the conditions of *le* and *ye* but not in the *bu* condition. The results show that 19-month-olds can categorize target words with succeeding functors. Moreover, the futility of the negation marker *bu* for backward categorization suggests toddlers' bias to categorize a word in the local phrase of the functor. Further, our findings validate toddlers' representation of functional elements in organizing phrases and bootstrapping grammatical categories.

Key words: grammatical categorization; language acquisition; functional morphemes; Visual Fixation Procedure; Mandarin

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List of Abbreviations

ASP	Aspect
AspP	Aspect phrase
CL	Classifier
CP	Complementizer phrase
DET/Det	Determiner
DP	Determiner phrase
FOC	Focus particle
FocP	Focus phrase
GEN	Genitive
IP	Inflection phrase
ISI	Inter-stimulus Interval
NEG	Negation marker
NegP	Negation phrase
NOM	Nominalizer/Relativizer
NP	Noun phrase
OBJ	Object
PERF	Perfective marker
PRON/Pron	Pronoun
SFP	Sentence-final particle
TP	Tense phrase
VP	Verb phrase
1s	First person singular

Chapter 1 Introduction

The role of functional morphemes for identifying content words like nouns and verbs in early language acquisition is the key to understanding whether, and if so how, young children represent the structure of their mother tongue. In recent years, the study of the perceptual link between functional morphemes and lexical items in young children has led to interesting findings concerning the configuration of children's linguistic knowledge at the initial stage. The present study evaluates the role of functional morphemes in bootstrapping abstract grammatical categories of nouns and verbs in Mandarin Chinese. [1]In this chapter, we will first introduce the background and significance of the present study and then outline the organization of this thesis.

1.1 Function Words and Affixes

The lexical-functional distinction is fundamental to linguistic theories (Carlson, 1983; Rizzi & Cinque, 2016; see Chomsky, 1965, for the distinction between lexical and minor categories). Elements that convey crucial conceptual information for semantic interpretation form an open class of lexical elements, namely content words or contentives (e.g., nouns, verbs, adjectives, and adverbs), whereas those associated with abstract "grammatical" meaning comprise a closed class of functional elements (e.g., determiners, copulas, and complementizers) incorporating both function words (free functional morphemes) and affixes (bound functional morphemes). For the terminology in this thesis, the term functional morphemes or functors will be used to include both function words and function affixes.

In English, for instance, functional elements subsume determiners (e.g., *the, this*), prepositions (e.g., *in, with, of*), inflections (e.g., tense markers *-ed*, *will*, and agreement markers -s), and complementizers (e.g., *that, whether, if*), as have been underlined in the following sentence.

(1) The little boy that asked his mom for a toy truck will get upset if he doesn't get it.

[1] In this thesis, the term 'grammatical categories' will be used interchangeably with 'syntactic categories'.

In Mandarin Chinese, functional elements also span across a wide array of particles including determiners (e.g., *zhe, na*), the modification marker or relativizer (i.e., *de*), classifiers (e.g., *ge, ben, gen*), pronouns (e.g., *wo, ni, ta*), negation markers (e.g., *bu, mei*), focus particles (e.g., *ye, dou, cai, jiu*), aspect markers (e.g., *le, zhe, guo*), and sentence final particles (e.g., *le, ne, ma*). The following sentence presents a Mandarin context with underlined functional elements.

(2) *nainai mai de na-ben shu jiage bu gui, yanse ye tinghao,*
grandma buy REL DET-CL book price NEG expensive color FOC nice
'The book that grandma bought is not expensive in price, its color also nice,
wo dou kan-le haoji-bian le ne.
I FOC read-ASP several-CL SFP SFP
even I have read it for several times already.'

A comparison of functional elements in English and in Mandarin Chinese would demonstrate that the particular group of words and affixes serving grammatical functions can vary significantly across languages. However, these abstract elements seem to constitute a unique and universal part of human language, as they involve grammatical computation and serve as the structural skeleton of individual languages. Given their crucial syntactic status, these functional elements are also termed in formal theories as functional categories for core theorizing (cf. Muysken, 2008; Ouhalla, 1991).

In terms of language acquisition, the knowledge of functional elements in young children has received considerable attention. In view of the poverty and inconsistent presence of functional elements in children's early production, many researchers endorse the idea that the words children primarily have access to are content words like nouns and verbs, given the support of their perceptible meaning and reference in the real world (e.g., Grimshaw, 1981). Their explanations for the absence of functional items include factors like brain maturation (e.g., Radford, 1996) and general cognitive learning mechanisms (e.g., Tomasello, 2002). On another view, functional elements are on the radar of infants from early on and play an essential role in how infants bootstrap the acquisition of their mother tongue – the idea of which culminated in the prosodic-functor bootstrapping hypothesis. Scholars upholding this view go beyond naturalistic data and posit that infants learning different languages can all perceive functional morphemes as a distinct category

due to their shared acoustic and distributional features across languages. To empirically test whether this knowledge is universal, they customarily opt for speech perception experiments involving behavioral (e.g., High Amplitude Sucking, Intermodal Preferential Looking, and Head Turn Preference) as well as neurophysiological techniques (e.g., Event-Related Potentials – ERP). These experiments turned out to be highly effective. The past few decades have witnessed mounting evidence in support of children's early or even inborn access to function words and affixes (see Dye, Kedar, & Lust, 2019, and Shi, 2014, for a comprehensive review of findings from this line of studies).

1.2 Significance of the Present Study

Given the debate between the two views concerning the accessibility of functional elements in infancy, the present study investigates the perception of functional morphemes by Mandarin-learning toddlers through the use of the Visual Fixation Procedure (modified from the Intermodal Preferential Looking Procedure). We ask whether functional morphemes might constrain grammatical categorization in Mandarin-learning toddlers and explore properties that can better characterize their mechanisms of grammatical categorization. Therefore in a broad sense, the present study serves as a cross-linguistic inquiry into the prosodic-functor bootstrapping hypothesis through the lens of Mandarin Chinese and thereby provides a crucial testing ground for the availability of grammatical categories in infancy that bears closely on the continuity hypothesis in language acquisition. Specifically, our study shall contribute to the field in the following three aspects.

First, we explore the new possibility of using aspect markers for verb categorization in Mandarin as a language with impoverished inflectional morphemes. Unlike previous studies that used pronouns as the bootstrapper for verbs (e.g., Höhle, Weissenborn, Kiefer, Schulz, & Schmitz, 2004; Shi & Melançon, 2010), the Mandarin aspect marker *le* is a functional element within the search space of the verbal predicate and might therefore serve as a more reliable predictor for an adjacent verb. It will be interesting to empirically examine the role of this marker, given its prominent prosodic and distributional properties as well as its notable occurrence in Mandarin input to mark a verb phrase.

Second, the present study touches upon the feasibility of using utterance-medial functional morphemes as a novel context for categorizing a preceding word. Previous studies in grammatical categorization either examined the frame (or trigram) distribution

pattern of *aXb* (e.g., *the _ and* as a noun slot and *to _ with* as a verb slot; e.g., Mintz, 2003) or looked at the bigram distribution pattern of *aX* (*your _* as a noun slot and *I _* as a verb slot; e.g., Shi & Melançon, 2010). Respecting the segmentation of the functor, our choice of a new context *XaY* for grammatical categorization is more challenging than those examined in foregoing studies, given that the utterance-medial functor *a* is not at salient phrase boundaries (Sundara, 2018). Additionally, unlike previous studies in which the functor *a* precedes the target word *X* (i.e., *aX*), the functor *a* in our study follows the target word *X* (i.e., *Xa*) while preceding the filler word *Y* (i.e., *aY*). This shall provide us with a window onto how infants parse functors when given a minimal context presenting one fixed functor in the middle and two changing lexical elements at the edge (e.g., *_ le _*, where the embedded functor is the aspect marker *le*).

Third, our choice of functors allows us to address whether toddlers conform to typical constructions in categorizing the target word *X* preceding the functor *a* in *XaY*. Though the utterance-medial functors in this study are all typical in Mandarin-learning children's early input, it would be instructive for us to see if typical constructions could consistently predict whether toddlers can backtrack to categorize the target word *X* preceding different functors, or contrariwise, whether the different syntactic structures underlying different functors might lead to uneven parsing outcomes, some of which unpredicted by formulae.

1.3 Organization of the Thesis

This thesis falls into seven chapters. Chapter 2 reviews key literatures in grammatical categorization, including different views concerning the development of grammatical categories, the theory of and evidence for the prosodic-functor bootstrapping hypothesis, and the acquisition of grammatical categories in Mandarin. Chapter 3 provides the rationale, together with the Mandarin functors under investigation, and the experimental design of the study including the research questions and the methodology. Chapter 4 covers the results and discussions of the study. Chapter 5 centers on a follow-up study by presenting its objectives, methodology, results, and discussions. Chapter 6 discusses general issues concerning findings from our experiments in relation to prior studies. Chapter 7 presents a summary of our major conclusions based on our findings as well as their implications for language acquisition.

Chapter 2 Literature Review

In this chapter, we will first review in section 2.1 two different views concerning the development of grammatical categories in children and the bootstrapping mechanisms proposed for how abstract grammatical categories can be acquired from scratch. Next in section 2.2, we will elaborate on the prosodic-functor bootstrapping hypothesis as our working hypothesis together with empirical evidence for the hypothesis. Section 2.3 will be devoted to the acquisition of grammatical categories in Mandarin, including both findings and proposals from previous studies and the linguistic properties of functional elements we expect to examine in exploring the potentials of uncharted functors for bootstrapping grammatical categories in Mandarin Chinese.

2.1 Grammatical Categorization

One of the crucial tasks for infants to acquire the rudiments of their first language is the assignment of words to their corresponding grammatical categories like nouns and verbs, or simply put, grammatical categorization. The syntactic category of a word determines its occupiable positions in a clause, the type of words with which it co-occurs, and the types of morphemes it accepts. Understanding how children assign grammatical categories to words contributes greatly to theories of language acquisition, as it reveals children's early generalization of the combinatorics of elements in a given sentence and bears on the debate whether grammatical categories belong to their innate linguistic knowledge.

Often referred to as an epitome of subconscious grammatical categorization, Lewis Carroll's (1964) poem *Jabberwocky* presents us an insight into how grammatical categories are part and parcel of adults' interpretation of novel words. Upon hearing a sentence *slithy toves did gyre and gimble in the wabe*, it is easy for us to learn that *tove* is a noun and *gimble* a verb by observing their neighboring words. Conventionally, such an ability to derive the syntactic category of a novel word is attributable to adults' knowledge of the combinatorics of phrases in a given sentence. This very phenomenon has naturally led researchers to question whether early grammatical generalizations like grammatical categories have likewise surfaced in infants. Will it be a challenge for toddlers to analyze syntactic structures? Unlike adults who can refer to parts of speech of individual words

in learning a second language, toddlers are often faced with incomprehensible speech and never receive explicit instructions on how to break phrases down into syntactically defined units. Exploring the approaches toddlers follow in addressing this challenge is hence revealing of the mechanisms underlying preliminary word learning.

2.1.1 Abstract Grammatical Categories vs. Usage-Based Formulae

According to nativists, grammatical categories are innately endowed in infants as a fundamental component of their inbuilt language faculty known as Universal Grammar (e.g., Chomsky, 1965; Pinker, 1984; Valian, Solt, & Stewart, 2009). This approach is commonly known as the Continuity or Full Competence Hypothesis. The strong version of this hypothesis suggests that children have access to abstract grammatical categories as well as other principles of language at all stages and come to identify parametric values from early on (e.g., Crain, 1994; Yang, 2013). Recognizing the knowledge of grammatical categories and their origin, the weaker claim emphasizes that these categories are gradually mapped to the specific grammar children are exposed to (e.g., Lust, 1999; Santelmann, Berk, Austin, Somashekar, & Lust, 2002).

The constructivist view, however, denies the presence of such independent abstraction of grammatical categories in young children and contends that they simply memorize item-specific formulae through usage-based distributional analysis (e.g., Pine & Lieven, 1997; Tomasello, 2000). To put it differently, grammatical constructions in children's mind are not represented in structurally defined grammatical categories at the initial stage; rather, constructions spring from interactional conventions, and that early children can only combine concrete pieces of language they comprehend and use early pivot schemas to partition scenes they are capable of conceptualizing with different words (cf. Goldberg, 1995). Abstractions of paradigmatic categories as nouns and verbs emerge only at a later stage as exemplars that are entrenched with token frequency through general cognitive processes (i.e., intention-reading and pattern-finding) and is limited to concrete linguistic items, namely particular words or phrases that repeatedly fulfill the same communicative functions across utterances and constructions (Tomasello, 2003).

Though both nativist and constructivist approaches suggest a role for distributional analysis, the two approaches differ significantly in whether the analysis is independent of contexts and what motivates the analysis. Constructivists hold that children's distributional analysis for abstracting constructions is a meaning-based process of finding

analogical patterns across utterances according to the concrete communicative functions they serve, which is only possible after they have stored enough pieces of meaningful clusters. This abstraction of utterance patterns is performed primarily to achieve social ends, namely to facilitate their comprehension and production of utterances in the language community (Tomasello, 2009). From the perspective of nativists, however, the distributional analysis by early children dispenses with components of meaning (i.e., reference and motive) and is syntactically defined in terms of phrases and grammatical categories; such analysis, being formal in essence, is fundamentally driven by children's language faculty to link content words to their abstract, innate grammatical categories (cf. Valian et al., 2009). The crucial issue for acquisition researchers to justify the linkage to grammatical categories then is to formulate and testify to a theory capable of elucidating the learning mechanisms at work upon infants' first foray into lexical categories and the sources of cues infants might marshal to trigger the corresponding mechanisms.

2.1.2 Bootstrapping Grammatical Categories

As a system of mechanisms predicated on the framework of principles and parameters, bootstrapping models have been developed by nativists to explain how infants' representation of grammatical categories (as a part of their congenital linguistic knowledge) can be linked to content words (as component properties of the particular language) through interfaces between different domains (or modules) and the language faculty (for a review of the ramifications of bootstrapping mechanisms, see Höhle, 2009). Respecting the specific kind of input to activate the innate linguistic knowledge, bootstrapping hypotheses encompass the idea that cues like real-world contingencies (semantic bootstrapping; Pinker, 1984), syntactic structures (syntactic bootstrapping; Gleitman, 1990; for a recent review, see Fisher, Jin, & Scott, 2019), and phonological analysis of the speech signal (phonological bootstrapping; Morgan & Demuth, 1996) support children in the acquisition of lexicon and their syntactically defined properties.

Semantic bootstrapping, first introduced by Pinker (1984), hypothesizes how meaning assumes the role of establishing the rudimentary linking rules for connecting semantic entities and their corresponding grammatical categories – namely, objects are denoted by nouns while actions by verbs. This idea of meaning being the primary source of support is nevertheless challenged by evidence showing that blind children do not lag behind their sighted peers in acquiring the distinction between verbs like *look* and *see* and

without relying on the visual world for such cues (Landau & Gleitman, 1985).

As an alternative bootstrapping model underscoring perception data from infancy, the prosodic-functor bootstrapping hypothesis squarely addresses the problem of word categorization by highlighting perceptual differences between lexical and functional morphemes. Specifically, it predicts that from early on, infants become aware of functional morphemes or functors by noticing their distinguishable acoustic properties and distributional regularities (Morgan, Shi, & Allopenna, 1996).[1] This finite set of functional items, together with prosody, provide infants with promising avenues for segmenting speech and deriving syntactic abstractions to learn about the grammatical categories of new words (also see Christophe, Guasti, Nespor, Dupoux, & van Ooyen, 1997, for its earlier model).

2.2 Prosodic-Functor Bootstrapping Hypothesis

The prosodic-functor bootstrapping model can be understood in terms of three central features (Christophe, Millotte, Bernal, & Lidz, 2008) – a prelexical phonological representation featuring phrasal prosody, a special lexicon of function words in syntactic processing, and the function-word-stripping process to derive syntactically informative lexicon. At its core, this mechanism enable infants to assemble toolkits of phrasal prosody and functional elements and use them in decoding utterances in real-life scenarios, where the bulk of sentences they initially hear are devoid of familiar words.

2.2.1 Segmentation with Prelexical Phonological Representation

First and foremost, a prelexical phonological representation allows children to segment between units. It has been observed across languages that every prosodic phrase boundary always coincides with a syntactic boundary, or X" (Christophe et al., 1997; Nespor & Vogel, 1986; for a review, see Shattuck-Hufnagel & Turk, 1996). Meanwhile, the prosodic structure is not perfectly reflective of its corresponding syntactic structure, as not all syntactic boundaries are prosodically marked (cf. Chomsky & Halle, 1968).

The role of prosody proposed for preliminary speech segmentation is indeed supported by infants' early processing of phrasal prosody (e.g., Christophe, Dupoux,

[1] Though distributional properties alone can contribute to grammatical categorization, we do not adopt distributional bootstrapping as our working model, as it underlines the computation of nonprosodic statistical properties of the input (namely at levels of phonemes, syllables, and morphemes), whereas in our present study, prosody and functors are framed as crucial elements for grammatical categorization.

Bertoncini, & Mehler, 1994; Hallé, Durand, & de Boysson-Bardies, 2008; Mehler et al., 1988; Shi & LePage, 2008). For instance, infants react to the disruption of phonological phrases (e.g., Gerken, Jusczyk, & Mandel, 1994; Jusczyk et al., 1992) and are assisted by phrasal prosody in acquiring the head-direction parameter of their mother tongue (Christophe, Nespor, Guasti, & van Ooyen, 2003; Mazuka, 1996; Morgan, 1986).[1] Besides, such cues also serve to constrain infants' lexical access (e.g., Gout, Christophe, & Morgan, 2004, for English; Millotte, 2005, for French; for data from adults, see Christophe, Welby, Bernal, & Millotte, 2005).

To look at the role of prosody in infants' grammatical categorization, Massicotte-Laforge and Shi (2015) familiarized French-learning 20-month-olds with a sentence ambiguous between two syntactic structures, [[*Ton*$_{\text{Det}}$ *felli*$_{\text{Adj}}$ *crale*$_{\text{N}}$]$_{\text{NP}}$ [*vur*$_{\text{V}}$ *la*$_{\text{Det}}$ *gosine*$_{\text{N}}$]$_{\text{VP}}$] versus [[*Ton*$_{\text{Det}}$ *felli*$_{\text{N}}$]$_{\text{NP}}$ [*crale*$_{\text{V}}$ *vur*$_{\text{Prep}}$ *la*$_{\text{Det}}$ *gosine*$_{\text{N}}$]$_{\text{VP}}$]. To resolve this syntactic ambiguity, toddlers had to attend to their distinct prosodic boundaries. After familiarization with one of the two prosodic structures categorizing *crale* either as a noun or a verb, infants were exposed to alternating test trials of 'Det + N' (e.g., *Le*$_{\text{Det}}$ *crale*$_{\text{N}}$ 'the crale') versus 'Pron + V' (e.g., *Tu*$_{\text{Pron}}$ *crales*$_{\text{V}}$ 'you crale'). The results revealed that they listened longer to grammatical trials that matched the intended syntactic category of the target word during familiarization, meaning that they had perceived the prosodic cues for categorization. In another recent study using an Intermodal Preferential Looking Procedure, researchers investigated whether infants were able to resolve temporary lexical ambiguity by exploiting prosodic cues (Carvalho, Dautriche, Lin, & Christophe, 2017). French-learning 20-month-olds were presented with a locally ambiguous test sentence where a noun-verb homophone [suʁi] was used either as a noun in [*le bébé* ***souris***] [*a bien mangé*] ([the baby **mouse**] [ate well]) or as a verb in [*le bébé*] [***sourit*** *à sa maman*] ([the baby] [**smiles** at his mother]), as they watched two pictures shown side-by-side on a TV screen, one displaying the noun interpretation (e.g., image of a mouse) and the other the verb interpretation (e.g., image of a baby smiling).[2] The results demonstrated that infants successfully switched their eye-gaze to the matching image upon hearing the ambiguous target word, indicating that they had captured the prosodic

[1] In the principle and parameter model forwarded by Chomsky (1981), the head-direction parameter is crucial to syntactic analysis in the sense that this parameter is informative of how words are arranged within phrases and phrases within sentences. In particular, such a syntactic property is represented by X-bar schema to restrain possible phrase structures in a given language: complements are sisters to the head (X) which occur to the left of X in left-branching languages and to the right of X in right-branching languages.

[2] The brackets indicate prosodic phrase boundaries.

cues (a prosodic boundary preceding the ambiguous word when it was used as a verb but not so when it was intended to be a noun) to recover the syntactic structure and thereby determine the intended meaning of the ambiguous homophone.

2.2.2 Using Functional Morphemes for Grammatical Categorization

Functional morphemes serve the crucial role of gluing together individual lexical items and mark the structural relations between them. Theoretically, by attending to the distributional properties of functional morphemes, infants can identify phrase structures (e.g., noun phrases or verb phrases) to derive abstract representations (cf. Cann, 2000). In the meantime, the function-word-stripping procedure assumed by the prosodic-functor bootstrapping hypothesis further guarantees that content words immediately adjacent to function words can be extracted and independently accessed by infants.

Though naturalistic data seem to point to the lack of function words and inflections in children's spontaneous speech before three years of age (Brown, 1973), empirical studies have given proof to infants' sensitivity to functional items from the onset of acquisition, demonstrating that infants indeed perceive functional morphemes as belonging to a distinct category even in their first year of life. It has been found that few-day-old infants are nevertheless capable of distinguishing function words from content words (e.g., Shi, Werker, & Morgan, 1999). After 6 months of age, they have been able to track and represent some function words for speech segmentation (e.g., Höhle & Weissenborn, 2003; Shi, Marquis, & Gauthier, 2006), and by around 11 months old, they have obtained considerable sensitivity to most functors in their own native language (e.g., Hallé et al., 2008; Shady, Jusczyk, & Gerken, 1998; Shi, Werker, & Cutler, 2006; electrophysiological responses in Shafer, Shucard, Shucard, & Gerken, 1998). After one year of age, infant begin to parse sub-lexical or bound functional morphemes in several languages (French in Marquis & Shi, 2012; English in Mintz, 2013; Japanese in Haryu & Kajikawa, 2016) and can detect the ill-formedness of sentence in which the positions of functors have been displaced (Shady, 1996; Soderstrom, White, Conwell, & Morgan, 2007). Roughly by 18 months of age, they discriminate a broader range of structures linked to functional morphemes (Kedar, 2007) and track discontinuous dependencies between two functional morphemes (Höhle, Schmitz, Santelmann, & Weissenborn, 2006; Nazzi, Barrière, Goyet, Kresh, & Legendre, 2011; Santelmann & Jusczyk, 1998).

Thus far, evidence regarding the role of functors for grammatical categorization

comes primarily from studies looking at two different distribution patterns of functors – frame distribution (i.e. *aXb*) where the target word *X* is surrounded by two functors that frequently co-occur, and bigram distribution (i.e. *aX*) where the preceding functor suffices to categorize the following target word (for discussion of the two types of distributional information, see Mintz, Wang, & Li, 2014).

Adopting a variation of the Headturn Preference Procedure to examine the feasibility of bigram distributions, Höhle et al. (2004) found that German-learning 16-month-olds showed early categorization of novel nouns after listening to "determiner + noun" sequences (e.g., *ein pronk* 'a pronk') but not of novel verbs when given "pronoun + verb" phrases (e.g., *sie pronk* 'she pronks'). This was reflected by the difference in their looking times towards the matching and mismatching test passages, one where the novel word was a noun (e.g., *Das kleine Kind vergaß den Pronk dort* 'The little child forgot the pronk there') and the other where it was presented as a verb (e.g., *Meistens pronk er auf der großen Lichtung* 'Most of the time he pronk(ed) in the big clearing'). Using a similar design to look at younger infants, Shi & Melançon (2010) reported that French-learning 14-month-olds likewise categorized nouns but not verbs in their study. What is special about their study is that instead of presenting complicated sentential context in the test phase, their stimuli for both familiarization and test phases followed the pattern in which only a certain group of functors (e.g., determiners like *des* 'some', *ton* 'your', *le* 'the', or pronouns like *je* 'I', *il* 'he', *tu* 'you') preceded the nonsense words (i.e. *mige* and *crale*), and the functors during the test phase (*le* vs. *tu*) did not overlap with those in the familiarization phase (*des, ton* vs. *je, il*) to strictly test for infants' groupings with the functors. In addition, they also controlled for the prosodic differences of nonsense words in noun and verb environments so as to directly investigate whether distributional cues furnished by the functors alone contribute to grammatical categorization.

For grammatical categorization with frame distribution, the majority of studies center on distributional analyses of corpora in different languages (cf. Moran et al., 2018).[1] The informative cues provided by frequent frames, first uncovered in English by Mintz (2003), have been thus far corroborated by several studies looking at infant-

[1] Some studies, while employing frame distribution as a cue for the syntactic category of novel words in a sentence, present infants with simple motion events performed by an animated agent for the purpose of training them to map a novel noun to an object/entity and a novel verb to an event (e.g., He & Lidz, 2017). The present study only examines grammatical categorization of novel words without any accompanying dynamic scenes intended for further mapping (of the syntactic category of a word to its conceptual category); therefore, we do not touch upon this line of studies in our review of literatures.

directed speech in other languages. Using the Headturn Preference Procedure, Mintz (2006) tested 12-month-old American infants using a similar design with Gerken, Wilson, and Lewis (2005). Nonsense target words were presented to infants in full sentences involving either noun frames (e.g., *the _ in*; *his _ on*) or verb frames (e.g., *to _ it*; *you _ the*). Different from findings with bigram distribution, infants exposed to frame distribution only categorized verbs but not nouns.[1] Altogether, these results indicate that early toddlers already have the capability of labeling novel words (as a noun or a verb) according to their immediately adjacent function words. Most of the studies point to the observation that for infants below 16 months of age, categorization of nouns emerge prior to that of verbs when they are given bigram cues (partially due to the reliability of syntactic context); nevertheless, there is evidence that infants (i.e., English-learning 12-month-olds) can successfully categorize verbs, given frame cues within sentences (Mintz, 2006).

The empirically validated role of functional morphemes in supporting grammatical categorization in the aforementioned studies can be explicated in terms of their distributional and perceptual properties as well as their grammatical weight. With respect to distribution, functional morphemes occur frequently at the edges of prosodic units (Maratsos & Chalkley, 1980). Perceptually, functional morphemes are characterized by lack of stress, short syllable duration, null coda, weak prosody, vowel harmony, and mono-syllabicity cross-linguistically (Gervain, Nespor, Mazuka, Horie, & Mehler, 2008; Monaghan, Christiansen, & Chater, 2007; Morgan et al., 1996; Shi, Morgan, & Allopenna, 1998). Furthermore, regarding their grammatical weight, functional morphemes are assumed by generativist syntacticians to form functional categories that head phrases or functional projections to take lexical items in formal analysis. Arguably, functional categories are believed to be represented in children's innate or afterwards matured grammar (Poeppel & Wexler, 1993; Borer & Rohrbacher, 1997; Radford, 1995, 1996; for a discussion, see Guasti, 2002).

Given the special status of functional morphemes, it would behoove researchers to

[1] Judging from the familiarization sentences used in Mintz's experiment, we surmise that infants' failed categorization with novel nouns in the experiment could be attributed to two possibilities. The first is that noun sentences like 'I see the gorp in the room' or 'I put his gorp on the box' generally involve two objects (e.g., an irrelevant noun *room* or *box* in addition to the novel noun itself), unlike verb sentences like 'I deeg you now' or 'Can you lonk the room' that contain one object at most. This was the case for both the familiarization phase and the test phase and might have increased the load for processing noun sentences. The second is the inflexibility of substituting nouns in the selected noun frames. That is, the substitution of novel noun *gorp* in 'I put his gorp on the box' for another novel noun *bist* in 'Here's a bist of a dog' might not be licensed for reason of the semantic incompatibility between the two constructions, which could essentially befuddle infants.

scrutinize whether such sensitivity to functional items can be a natural aptitude universal to infants learning different languages. As the conclusion that functional morphemes facilitate grammatical categorization rests on previous studies focusing on inflectional languages, it leaves us with the essential question whether infants acquiring a non-inflectional language are also able to exploit functional morphemes in their language for grammatical categorization. Therefore, examining grammatical categorization in infants learning a language with fewer grammatical markers will help us understand whether functional items can be part of children's shared innate knowledge for mapping lexical items to grammatical categories.

2.3 Acquisition of Grammatical Categories in Mandarin

Unlike Indo-European languages that have a rich repertoire of grammatical morphemes (e.g., articles, plural morphemes, and subject-verb agreement), Mandarin is a language lacking affixes or particles to indicate word classes. Quite the opposite, it is still widely debated whether a clear-cut distinction can be made in Mandarin Chinese for word categories like nouns and verbs (Shen, 2007). Understanding the type of cues Mandarin-learning infants exploit to disclose the categories of words would therefore not only conduce to the formulation of theories, but it would provide us with insights into learnability issues of human language.

2.3.1 Distributional Cues for Grammatical Categories in Mandarin Input

There is evidence that frame distribution and bigram distribution are statistically sufficient for Mandarin children to predict the grammatical categories of words adjacent to functional morphemes.

Xiao, Cai, and Lee (2006) suggest that frames allow learners to categorize about one-quarter of the words in the input. Specifically, they demonstrated that the sentence-final *le* in Mandarin can reliably predict its preceding word to be a verb when co-occurring with the negation marker *bu* in the frame "*bu* _ *le*", meaning 'stop doing something'. In another corpus study by Lee and Naigles (2005) looking at the viability of syntactic bootstrapping for verb learning in Mandarin Chinese, the perfective aspect marker *le* was included specifically as one of the three unique structures in Mandarin for verb

categorization.[1] Furthermore, the possibility of *le* being a potential cue for grammatical categorization is warranted, given the prosodic distinctiveness and early acquisition of *le* supported by previous literature (Lee, 1996). Specifically, it indicates that among all aspect markers which make up 14.3% of all verb frames under investigation, the aspect marker *le* occurs 83.5% of the time and seems to be compatible with verbs across extensive semantic classes. A more recent study focusing on bigram distribution in child-directed speech have also testified to the reliability of the aspect marker *le* in predicting a preceding verb (Ma, Zhou, Golinkoff, Lee, & Hirsh-Pasek, 2019).

2.3.2 Experimental Inquiries of Grammatical Categories in Infancy

Though evidence from corpus analysis of Mandarin input suggests structural cues for grammatical categorization, the empirical side of the story has rarely been charted. The majority of studies looking at infants' acquisition of nouns and verbs place the focus on whether infants are able to map the words they hear to their corresponding conceptual categories – that is, whether a word refers to an object or an action in a dynamic scene. For instance, Chan et al. (2011) investigated whether infants habituated to label-to-scene pairs can map the label to its reference in the visual world, and the results show that English learners mapped both objects and actions at 18 months but neither objects nor actions at 14 months, while Mandarin learners only mapped the actions at both 14 months and 18 months. These findings seem to suggest that Mandarin infants by the early age of 14 months have established a more robust conceptual category of verbs than nouns as to what they refer to in the real world; what cannot be concluded from experiments of this kind is whether infants can abstract grammatical categories from words presented in pure sentential structures, i.e. in absence of the concept of words embodied in dynamic scenes.

To our knowledge, only one study by Zhang, Shi, and Li (2014) empirically investigated the grouping of grammatical categories in Mandarin-learning infants, concluding that 12-month-olds can exploit functors to categorize their immediately succeeding words. To be specific, infants were familiarized with both noun contexts and verb contexts in which certain functors preceded ambicategorial words (disyllabic words

[1] As a notion linked to temporal reference, aspect encodes different angles of observing the internal temporal structure of situations (Comrie, 1976; Smith, 1991). Two types of aspect, namely grammatical aspect (or viewpoint aspect) and lexical aspect (or situation aspect) have been discussed in literature (for a recent review, see Tonhauser, 2015). Grammatical aspect bears on how an event is perceived by the speaker and marks the perfective and imperfective distinctions (e.g., *-ed* and *-ing* in English). Perfective marker *le* is widely used for encoding temporal relations through demarcating event boundaries in Mandarin, a language in absence of overt tense.

that are used either as nouns or verbs depending on the syntactic context; i.e., *yanjiu* 'research; to research', *jianyan* 'evaluation; to evaluate', *faming* 'invention; to invent'). The noun context type presented *wode* 'my' and *zhege* 'this' to indicate a subsequent noun, and the verb context type included *woye* 'I also' or *nibie* 'you don't (imperative)' to suggest a subsequent verb. Of the six possible combinations for each context type (noun context: *zhege yanjiu, wode yanjiu, zhege jianyan, wode jianyan,* ***zhege faming****, wode faming*; verb context: *woye diaocha, nibie diaocha, woye tongji, nibie tongji, woye bianlun,* ***nibie bianlun***), the ten sentences in normal font were presented during familiarization; the rest two sentences in bold font (***zhege faming***$_{N}$ and ***nibie bianlun***$_{V}$) were reserved for the subsequent test phase to be contrasted against ungrammatical combinations (*nibie faming*$_{V}$ and *zhege bianlun*$_{N}$). According to the results, infants did not show distinction between grammatical and ungrammatical trials in the first half of the test phase, but they listened significantly longer to ungrammatical trials in the second half as a block.

While Zhang et al. (2014) demonstrated that 12-month-olds are able to learn grammatical categories, the study familiarized all subjects with both nouns and verbs and used overlapping functors (i.e. *zhege* and *nibie*) between the familiarization phase and the testing phase, a design similar to that of Gerken et al. (2005), so as to test whether younger infants around one year of age can generalize combinatorial regularities from familiarization contexts that are fully informative (i.e., no new contexts in the following test phase). However, other parallel studies looking at older infants or toddlers (aged 14-16 months old) learning Indo-European languages (e.g., French by Shi & Melançon, 2010) familiarized subjects with either noun contexts or verb contexts and employed different sets of functors during the familiarization phase ($\{des/ton\}_{Det}\ X_{N}$ vs. $\{je/il\}_{Pron}\ X_{V}$) and the test phase ($le_{Det}\ X_{N}$ vs. $tu_{Pron}\ X_{V}$), and that the functors during the test phase were different for grammatical and ungrammatical trials (for details of the study, see section 2.2.2). This design is crucial for testing toddlers (over one year of age) in the following aspects: first, it serves to probe for toddlers' expectation concerning other functors that are able to co-occur with the familiarized target words; second, it helps to rule out the possibility that toddlers may be simply memorizing the matching contexts from the familiarization phase; third, for each subject, the target words are of the same category, thus allowing the assignment of grammatical categories to be less memory-intensive. Given the need to follow this design in testing and thereby understanding how Mandarin-

speaking toddlers' grammatical categorization develops, in comparison to that of toddlers learning Indo-European languages, the present study is motivated.

To recapitulate, regarding the distribution pattern of functional morphemes for grammatical categorization so far examined in infants, previous studies either looked at frame distribution in which two functors co-occur to enclose a content word for constraining its syntactic category (e.g., Mintz, 2006), or investigated bigram distribution in which an individual functor (like a pronoun or a determiner) precedes a content word (e.g., Höhle et al., 2004). To further reveal the assortment of functors that infants perceive at different utterance positions, we introduce utterance-medial functional morphemes (i.e., functor *a* between the two lexical elements of *X* and *Y* in a three-word sequence *XaY*) into the experimental design of the present study and, from the perspective of Mandarin (a language impoverished in grammatical morphemes), address the combinatorial characteristics of functional morphemes that are well-suited for bootstrapping grammatical categories.

Chapter 3 The Present Study: Rationale and Experimental Design

This chapter states the rationale of the present study and presents the layout of our experiment design, including the research questions and the methodological clarifications for the experiment.

3.1 Rationale

In brief, one rationale has motivated the present study. That is, it endeavors to further explore what types of functional morphemes (or functors) serve as structural cues that infants exploit for grammatical categorization, so as to shed new light on the attributes of syntactic structures on which infants zero in. As reviewed earlier in Chapter two, psycholinguistic studies have evidenced infants' sensitivity to functional morphemes as a perceptually and distributionally distinct category. In the meantime, functional categories are also recognized as essential structural skeletons in formal analysis to join lexical elements. Given the convergence between the two, it is exciting to see how psycholinguistic studies and syntactic theories can be bridged and enrich more profound understandings of the mechanisms of language learning.

As the previous study by Zhang et al. (2014) selected free morphemes in Mandarin to test infants' capability of grammatical categorization, it still leaves us with the question whether Mandarin-learning children also perceive functional morphemes in the category of bound morphemes. Also, given our interest in the continuity hypothesis in language acquisition, the present study primarily looks at structures (with functional morphemes) not yet present or productive by 18 months of age. Based on these considerations, this section also profiles the potential Mandarin functors we intend to examine in the present study for grammatical categorization.

First, we include *le* as a potential bootstrapper for categorizing new verbs in our experimental context for its frequent occurrence in adult input. Assuming psychological mechanisms for infants to attune themselves to the validity of cues, we justify the strength of a functor for categorization by calculating its cue validity, following MacWhinney, Pleh, and Bates (1985). The cue validity of *le* is 0.008, given its cue availability (1.67%

in the transcripts of Tong's corpora at the two ages of 19 and 20 months old in CHILDES[1]) and its cue reliability (46%; cf. Ma et al., 2019).[2] To be exact, we look at the perfective aspect marker *le*, also known as the verb suffix *-le*.[3] The morpheme is unstressed (hence carrying a neutral tone) and requires a subsequent complement, either an object or a duration phrase, as shown in the following examples (Chao, 1968; Lu, 1980; Zhu, 1982).

(3) a. *Xiaoming* *kan-le* *san-ben* *shu.*
Ming read-PERF three-CL book
"Ming (has) read three books."
b. *Xiaoming* *shui-le* *san-ge* *xiaoshi.*
Ming sleep-PERF three-CL hour
"Ming (has) slept for three hours."

Second, to create a categorization contrast against *le* as a verb predictor, we chose another equally frequent functional morpheme, namely the negation marker *bu*, as it emerges early in infant speech production (Fan, 2007).[4] Its cue validity is 0.006, given its cue availability (3.51%) and cue reliability (18%) in the abovementioned corpora (cf. Deng & Yip, 2018). The negation marker *bu* is articulated (with a falling tone) and expresses a rightward scope of negation typically over its verbal predicate, as is exemplified by the sentence below.

[1] The transcripts contain a combined total tokens of 8320. Tong corpus is part of a larger project led by Xiangjun Deng and Virginia Yip (2018). This Mandarin corpus covers the naturalistic interactions between a Mandarin-speaking child Tong and his caregivers from age 1;0 to 4;5. As a child raised in Shenzhen, China where Mandarin is spoken as the official language, Tong also received some Cantonese and English input from 2;5 in kindergarten in Hong Kong where Cantonese was used as the language for instruction. We only analyzed the earliest input available in the corpus, in which Mandarin was used as the only language for communication.

[2] By definition, cue validity is the product of cue reliability times cue availability. Cue availabillity is numerically defined as the ratio of the cases where a cue is available over the total cases in the task domain, whereas cue reliability is numerically defined as the ratio of the cases where the cue leads to correct assignments over the cases where it is available.

[3] *Le* constructions encompass two major cases: firstly, *le* serves as a verb suffix (known as le_1), as in the pattern "VP-*le*+NP", which indicates realization or perfectivity of its preceding verb (or verbal phrase); secondly, *le* is identified as a sentence-final particle (known as le_2), as in patterns of "VP+*le*" and "VP+NP+*le*" (e.g., Li & Shirai, 2000, p. 94-95; Wang, 2006; Zhang & Wang, 2009), which lacks a unified account but is widely accepted as expressing currently relevant state (Li & Thompson, 1981). In line with the observation that sentence-final particle *le* does not suffice to predict its preceding phrase to be a verb phrase, whereas the verb suffix *-le*, namely aspect marker *le*, does, this study only investigates verb suffix *-le* as a potential bootstrapper for categorizing verbs, as it figures as a syntactically more reliable predictor for verbs.

[4] Though negation seems to be a hybrid of a functional and lexical word (cf. Atkinson, 1992), it is unclear what theta-role negation can assign (as one of the defining features for lexical categories; Grimshaw, 1990). For this study, we treat negation as a functional category in line with Pollock's (1989) proposal of the NegP.

(4) *Xiaoming* *bu* *jiaoshu*.
Ming NEG teach
"Ming does not teach."

In a typical negation construction like this, the negation marker *bu* stands in between a preceding subject-NP and a succeeding predicate. Indeed, this is representative of toddlers' early speech input where negation constructions commonly feature a noun preceding the negation marker.

This choice of functional morphemes allows us to gain an insight into the puzzle of grammatical categorization in Mandarin-learning toddlers, namely, whether toddlers are committed to the typical structure associated with the functor, or if they would be predisposed to analyze the syntactic category of the target word in an unexpected manner.

3.2 Experimental Design

To present our design to investigate Mandarin-learning toddlers' sensitivity to functional morphemes for bootstrapping grammatical categories, we will first state the research questions and then introduce the experimental methodology we adopt for the present study.

3.2.1 Research Questions

In particular, we aimed to investigate whether functional morphemes might constrain grammatical categorization in Mandarin-learning toddlers and to explore properties that better characterize their mechanism of grammatical categorization. Specifically, the following two research questions will be addressed:

(1) Are they able to perceive and segment utterance-medial functional morphemes from continuous word sequences? Do they have the ability to compute the structure of these sequences with extremely limited morphosyntactic cues and correctly assign syntactic categories to target words preceding functional morphemes?

(2) Will different functional morphemes lead to different performances with grammatical categorization? If the results differ, what will they probably reveal concerning infants' mechanisms of morphosyntactic parsing?

3.2.2 Methodology

Visual Fixation Procedure. Traditional experimental methods in language acquisition for investigating older children's acquisition of functional morphemes include a production task (Zhou, Crain, Gao, Tang, & Jia, 2015), a picture selection task (Zhou, Crain, Gao, & Jia, 2017), and eye tracking (Ma, Zhou, & Golinkoff, 2019).[1] However, in the case of probing for infants' grammatical knowledge of phrases and sentences, the Headturn Preference Procedure or HPP (Hirsh-Pasek et al., 1987; Kemler Nelson et al., 1995) and its modified version, the Visual Fixation Procedure (Cooper & Aslin, 1990) are methods better suited, as these methods measure the length of time infants listen to a trial of auditory stimuli and compare their average listening time for two types of trials to see if they as a group show preference for one type of auditory stimuli (e.g., words, phrases, or sentences) over another.

The major difference between these two methods is whether the two types of auditory stimuli for testing come from the same source or two different sources. For HPP, infants initially face the front wall and then one type of auditory stimuli emanates from a certain side of the two side walls (i.e. the left wall or the right wall), requiring infants to turn their heads to the source of the sound; for the visual fixation procedure, infants listen to two types of auditory stimuli played one type at a time on the central screen, and the experimenter records the lengths of their looking times towards the screen.

As a central display of materials would better suit our experiment that involves a familiarization phase and a test phase, we adopted the Visual Fixation Procedure in the present study to test Mandarin-learning children's sensitivity to functors during their tasks of grammatical categorization.

Participants. 24 monolingual, normally developing Mandarin infants (12 boys, 12 girls; *M* age = 19 months 17 days; range = 18 months 5 days to 20 months 26 days) residing in Beijing participated in the study. These infants were randomly assigned to one of the two experimental conditions: the *le* condition or the *bu* condition (the *le* condition: 6 boys, 6 girls; *M* age = 19 months 22 days; range = 19 months to 20 months 9 days; the *bu* condition: 6 boys, 6 girls; *M* age = 19 months 13 days; range = 18 months 5 days to 20 months 26 days).

Another 17 infants participated in the test but their data were eliminated from the final analysis due to fussiness (2), failure to stay on task (no recovery of looking time to

[1] Here, older children refer to children aged more than three.

the post-trial; 9), ceiling (1), and dropout (5).

Stimuli. The two functional morphemes, i.e. *le* and *bu*, were embedded in an unintelligible 3-word sequence *XaY* (*a* being the functional morpheme) to render the initial target word *X* and the final filler word *Y* equally adjacent to the medial functional morpheme on the surface structure.

The initial, also target, words for categorization were two monosyllabic words, namely *SHAI* and *MAN*, which are phonologically unbiased towards either noun or verb and rarely stand alone as a free morpheme. These monosyllabic words are not the kind of words that parents would possibly use with children. The functional morphemes were followed by disyllabic words, including *tongji* 'calculation; to calculate' and *jianyan* 'examination; to examine'. The choice of these disyllabic words is due to two considerations: first, these are words that children are unfamiliar with; second, they are ambicategorial between nouns and verbs, therefore compatible with both types of familiarization contexts. Target words appeared either in two noun contexts, i.e., N + *bu4* + disyllabic unfamiliar word, *shi* (copula) + *zhege* (determiner, 'this') + N, or in two verb contexts, i.e., V + *le* + disyllabic unfamiliar word, *dou* (focus particle, 'all') + *keyi* (modal auxiliary, 'can') + V. Contexts containing either *bu4* or *le* were provided in the familiarization phase, whereas the other two more elaborate contexts, a noun context (*shi zhege* X_N 'be this-CL X_N') and a verb context (*dou keyi* X_V 'all may X_V'), were saved for the test phase.[1]

A native female Mandarin speaker recorded the stimuli in three different intonation patterns to prevent subjects from deriving patterned structures from an invariant sentential prosody, whereas each sentence in the test phase was recorded in two different intonation patterns for the same purpose.[2] Exemplars for each intonation pattern were controlled so that the prosodic cues of the target words as nouns versus as verbs were balanced. The same target words in the *le* condition and the *bu* condition were recorded with comparable acoustic features regarding duration, mean pitch, or mean intensity (for detailed prosodic values, see Table 3 in Appendix).

Design. Infants were assigned randomly to one of the two conditions – half of the toddlers heard the aspect marker *le* during the familiarization phase, while the other half heard the negation marker *bu*, as is shown in Table 3.1.

[1] The cue validity of *zhege* is 0.003 (cue availability 0.004; cue reliability 0.8), whereas that of *keyi* is 0.001 (cue availability 0.0007; cue reliability 1).

[2] The target words were stressed to be rendered more salient than filler words. Such stress is natural and applicable.

Table 3.1 Familiarization conditions and test items in the present study

Familiarization (T_{max}=30 s, ISI = 1200 ms)	
***bu* condition**	***le* condition**
SHAI *bu* tongji MAN *bu* tongji MAN *bu* jianyan SHAI *bu* jianyan	SHAI *le* tongji MAN *le* tongji MAN *le* jianyan SHAI *le* jianyan
Test (T_{max}=17.6 s, ISI = 1000 ms)	
Trial 1 *shi zhege* SHAI *shi zhege* MAN	
Trial 2 *dou keyi* SHAI *dou keyi* MAN	
Post-test	

The experiment included twelve trials, namely one familiarization trial, ten test trials, and one post-test trial. All these trials were infant-controlled in the sense that they were initiated by infants' gaze on the central screen and suspended once infants had been distracted for 2 seconds. At the very beginning, an attention-getter was presented for subjects to fixate on the center of the screen. Consecutively, the familiarization trial began, with a talking puppet (whose mouth movement had been synchronized with the auditory stimuli) in the middle of the screen repeatedly presenting the familiarization utterances until a predetermined total looking time of 30s was reached (for the familiarization criterion, see Shi & Melançon, 2010); if the subject looked away in the middle for 2 seconds, the attention-getter would pop up, but as the subject looked back to the central screen, the puppet presenting familiarization sentences would be back.

The subsequent test phase presented grammatical and ungrammatical trials alternatively in a pseudo-randomized fashion. Between any two trials, an attention-getter was inserted to guarantee infants' fixation on the central screen. The test trials would terminate if the infant looked away for 2 seconds or if the maximum trial length (17.6 seconds) was reached. In the post-trial phase, subjects saw a cartoon picture of a meadow accompanied by light music in the background and their looking time was examined to ensure their full participation in the previous test trials.

Our arrangement of functors in the familiarization and test phases was similar to that

of Shi & Melançon (2010), as the syntactic environments of target words in the test phase did not overlap with those available to subjects during the familiarization phase. It is also worthy of noting that our target words were in an utterance-initial position during the familiarization phase but were in an utterance-final position during the test phase; this design allows us to see whether toddlers have truly categorized the target words, despite their changed positions during the test phase.

For each familiarization sentence in the *bu* condition, the target word (either *SHAI* or *MAN*) preceded the negation marker *bu*, thus supporting the target word as a noun (e.g., *SHAI*$_{N}$ *bu tongji*). The *le* condition was designed to familiarize another group of subjects with the same target words and filler words, yet the intervening functional morpheme was the verb suffix *-le*, which supported the target word as a verb (e.g., *SHAI*$_{V}$ *le tongji*). The inter-stimulus interval (ISI) during the familiarization phase was 1200 ms for both conditions.

After familiarization, toddlers entered the test phase with two types of alternating test trials, each presenting two utterance types, either *shi zhege SHAI*$_{N}$ and *shi zhege MAN*$_{N}$ or *dou keyi SHAI*$_{V}$ and *dou keyi MAN*$_{V}$. Within a given test trial, the two utterance types were presented repetitively for four times in a pseudo-randomized order, and the grammaticality of the test materials in the same trial was reversed for toddlers assigned to different conditions (i.e., trials that were grammatical for the *bu* condition were ungrammatical for the *le* condition) due to the fact that the slots in the two types of frames licensed words of different syntactic categories (i.e., *shi zhege X*$_{N}$ or *dou keyi X*$_{V}$). For instance, when the target word *SHAI* and *MAN* were initially presented in the *bu* condition as nouns or in the *le* condition as verbs during familiarization, test trials presenting *dou keyi SHAI*$_{V}$ and *dou keyi MAN*$_{V}$ would be grammatical for the *le* condition but ungrammatical for the *bu* condition, while those presenting *shi zhege SHAI*$_{N}$ and *shi zhege MAN*$_{N}$ would be grammatical for the *bu* condition but ungrammatical for the *le* condition. As the syntactic category of target words in the test phase either conformed with or diverged from that in the familiarization phase, half of the trials would be grammatical and the other half ungrammatical. The grammaticality of the first test trial (whether it is grammatical or ungrammatical depending on the familiarization) was counterbalanced within each condition of familiarization. The maximum length of each test trial in both conditions was 17.6s, with ISIs of 1000 ms.

Procedure. After adjustment to the surroundings in the lab, the infant was guided

by a lab assistant into a dimly lit acoustic chamber and seated on the parent's lap in front of a 42-inch monitor. Auditory stimuli were played from loudspeakers on the two sides of the monitor. Prior to the testing procedure, the parents were instructed to put on headphones, through which masking music was played to stave off any interference with the infant's natural response to the stimuli. The researcher observed the subject outside the chamber through a monitor, pressing down or releasing the computer key to record looking time. The experiment was run by an experimental program, which was designed to present all trials in a prearranged order and record all looking times of subjects online.

Predictions. If toddlers used functional morphemes to categorize target words during the familiarization phase, they were expected to show longer looking times towards either grammatical test trials (showing a familiarity effect) or ungrammatical ones (showing a novelty effect). Specifically, if toddlers' grammatical categorization was not constrained by structural differences, they should succeed in both conditions by showing a preferential looking pattern for one of the two types of trials, given that both structures are typical in terms of cue validity and can be predicted in child-directed speech.

Chapter 4 Findings

4.1 Results

Toddlers' average looking times during the two types of test trials were calculated, and the results are shown in Figure 4.1.

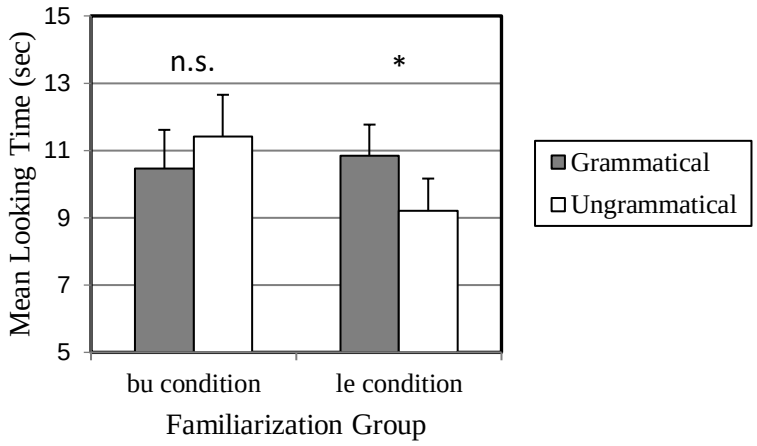

Figure 4.1 Mean looking times (and standard errors) during the two test trial types (grammatical vs. ungrammatical) for the *bu* condition and the *le* condition

To evaluate the performance of the two familiarization groups, paired *t*-tests were first conducted. Toddlers familiarized with the *le* condition looked significantly longer to the grammatical trials (M = 10.852 sec, SE = .917 sec) than to the ungrammatical trials (M = 9.199 sec, SE = .966 sec), $t(11) = 2.503$, $p = .029$, whereas those assigned to the *bu* condition did not show any distinction between the grammatical sentences (M = 10.461 sec, SE = 1.152 sec) and ungrammatical sentences (M = 11.415 sec, SE = 1.241 sec), $t(11) = -.710$, $p = .493$. According to results from paired *t*-tests, infants in the *le* condition exhibited grammatical distinction with a familiarity effect, whereas for those in the *bu* condition, a clear-cut grammatical distinction between the two types of trials was not observed.

A follow-up 2 x 2 ANOVA test was run for further data analysis, with Grammaticality (grammatical vs. ungrammatical) serving as one within-subject factor, and Condition (the *le* condition vs. the *bu* condition) as the other between-subject factor. The results demonstrated no effect of Condition, $F(1,22) = .473$, $p = .499$, and no effect of Grammaticality, $F(1,22) = .217$, $p = .646$. This indicates that the great extent of non-

distinction with infants in the *bu* condition offsets the significant grammatical distinction with infants in the *le* condition. In addition, the interaction between Grammaticality and Condition for all ten trials did not approach significance, $F(1,22) = 3.029$, $p = .096$, if we adopt the strict significance level of 0.05 for statistical analysis. This result was somehow unexpected, as our paired *t*-tests show that toddlers did show different looking patterns in the two conditions, and we anticipated there to be an interaction effect to suggest that infants' different performances in the two conditions were essentially due to the different conditions they were assigned to during the familiarization phase. Nevertheless, as the *p* value of .096 is very close to 0.05, we suspected that this could be a result of infants' equally short looking times for the last few trials due to boredom. To check this possibility, we removed the last four trials (where infants were possibly bored with the repetition of trials) and conducted the same 2×2 ANOVA test with the first six trials. As expected, the interaction effect between the two was significant, $F(1,22) = 5.210$, $p = .032$.[1] It is also the case that toddlers in the *le* condition manifested significant grammatical distinction, $t(11) = 3.721$, $p = .003$, whereas those in the *bu* condition did not, $t(11) = -.729$, $p = .481$. These findings further confirmed our prediction that infants can use function words to categorize adjacent words in a backward fashion, and that they succeeded in the *le* condition but failed in the *bu* condition.

4.2 Discussion

In the present study, 19-month-olds were tested on their sensitivity to utterance-medial function morphemes to derive the syntactic category of its preceding word, and the data from the task suggest that they succeeded in using the verb suffix *-le* to categorize its preceding verb but failed to use the negation marker *bu* to categorize its preceding noun.[2] In particular, subjects who were familiarized with the *le* condition looked significantly longer to grammatical trials (presenting the target words as verbs) than to ungrammatical trials (presenting the target words as nouns), whereas those familiarized with the *bu* condition failed to show a clear distinction between the two types of test trials.

This provides clear support for the prosodic-functor bootstrapping hypothesis in the sense that toddlers learning a non-inflectional language like Mandarin are just as able to

[1] We also calculated the interaction effect when only the last two trials were removed, and the interaction effect was also significant, $F(1,22) = 4.116$, $p = .055$. There was clear grammatical distinction in the *le* condition, $t(11) = 3.033$, $p = .011$, but no distinction in the *bu* condition, $t(11) = -.767$, $p = .459$.

[2] For the rest of the thesis, we will be using verb suffix *-le* and aspect marker *le* interchangeably.

exploit functors for lexical categorization as their peers learning Indo-European languages. However, if the syntactic category of the target word is taken as the only angle from which we interpret our findings, it would be tentative for us to conclude that Mandarin is a verb-friendly language, given our toddlers' better verb categorization, in contrast to better noun categorization in German- and French-learning 14- to 16-month-olds (Höhle et al., 2004; Shi & Melançon, 2010). Do our data truly imply a verb bias for grammatical categorization in Mandarin? Why did they fail in categorizing nouns?

One possibility to elucidate Mandarin toddlers' failure in the *bu* condition is the interference account. That is, some alternative structures of the negation marker *bu* might be competing with the conventional use of *bu* for negation, which is a likely cause for a reduced validity of its preceding word being categorized as a noun. One interesting fact about the negation marker *bu* in Mandarin is that despite its typical occurrence with a preceding noun, it can also serve in intuitively rarer cases to negate the potential of achievement in a negative potential construction, where the negation marker *bu* follows a verb and precedes a resultative complement, as instantiated by (5).

(5) *Kan* *bu* *qingchu.*
see NEG clear
"(I) cannot see clearly."

To see whether this account holds, we examined the weight of such noise in child-directed speech by analyzing two corpora of parental speech to the youngest Mandarin-learning infant in the CHILDES database (transcripts of Tong at the two ages of 19 and 20 months old, with a combined total tokens of 8320; cf. Deng & Yip, 2018), so as to ensure that such noise does not punish the more typical structure or interfere with toddlers' on-line categorization decisions. The results of our data analysis are shown in Table 4.1.

Table 4.1 Token number of selected functors serving as word class markers in input

	Marker	Description	Predicted class	Contrasting class	Another class
Noun-markers	bu4*	Negation marker	27	3	0
	zhege	Determiner	20	0	0
Verb-markers	le*	Perfective marker	6	0	0
	keyi	Modal auxiliary	6	0	0

Note: * is used to indicate that the marker predicts the word class of a preceding word (instead of a succeeding word).

Considering the results shown in the table above, it is reasonable for us to speculate that Mandarin-learning toddlers could be potentially aware of the far less frequent use of *bu* for negation of potential (i.e. X_V *bu Y* 'cannot X in a Y manner'), for they did not seem to be committed to the typical construction of negation (i.e. X_N *bu Y* 'X doesn't Y') in grammatical categorization.[1] Are the atypical cases of X_V *bu Y* (covering only 10% of all cases that are structurally relevant in the task domain) sufficient to suppress the parsing of the canonical structure X_N *bu Y*? To measure the impact of such noise, we applied the Tolerance Principle proposed by Yang (2016).

(6) **Tolerance Principle**: Let *R* be a rule that is applicable to *N* items, of which *e* are exceptions. R is productive if and only if $e \leqslant \theta_N = N/\ln(N)$.

Following the principle, we derive the number of exceptions e = 3, and $\theta_N = N/\ln(N) \approx 8.82$, therefore in our corpus, $e \leq \theta_N$. This suggests that the minor proportion of contradicting cases in Tong's corpora is far from reaching the threshold to compete with

[1] Only cases where the preceding word occurs at utterance-initial and clause-initial positions are included in the corpus analysis, given the compositional pattern of word sequences in our familiarization phase. If cases are added to the 'another class' category regardless of compositional patterns, including those where the negator *bu* in the corpora can be preceded by nothing (in an utterance-initial position; 32.3%), by the same word that also follows the negator (a reduplication construction known as A-*bu*-A questions as in *xiang-bu-xiang* 'do you want', *hao-bu-hao* 'is it okay', and *e-bu-e* 'are you hungry'; 39.2%), by an adverb (21 out of 27 adverb scenarios are monosyllabic focus adverbs as in *yi ni DOU bu-zhidao a* 'you don't EVEN know one'; 12.4%), or the particle *de* for introducing verbal complements (e.g., *na-de bu-dui* 'hold (it) in an incorrect way'; 2.3%), then the likelihood of the 'predicted class' would be reduced to 12.4%. The exclusion of these cases in our calculation comes of their irrelevance to the particular structure with which we primed toddlers for *bu* sentences, where the preceding words were monosyllabic ones acoustically dissimilar from the limited set of focus adverbs (e.g., *cai, jiu, dou, ye*) and at the same time phonotactically distinct from the pattern of A-*bu*-A (which is also prosodically prominent as a question and hence essentially different from our declarative *bu* sentences).

the highly canonical structure, where a noun precedes the negation marker *bu*. It is therefore reasonable to question if such exceptions have ever come across toddlers' mind or even impeded their analysis of the structure during familiarization. Furthermore, the interference account is equally weakened when acquisition studies on the negation marker *bu* are taken into consideration. The findings suggest that Mandarin-learning 20-month-olds still have trouble embedding the negation marker *bu* in between a verb and its resultative complement to indicate negation of potential; instead, they use *bu* predominantly in utterance-initial positions due to the omission of subject in Mandarin Chinese (Fan, 2007). It seems that the interference account does not elucidate the entire story of toddlers' unexpected categorization performance in the *bu* condition.

Alternatively, it is possible that toddlers' grammatical categorization is constrained by phrase boundaries. Following the idea that sentences are consisted of internal phrase structures, we examine this within-bounds account by comparing the phrase structures of familiarization sentences in the *le* condition and in the *bu* condition. What can be observed is that the familiarization sentences in the two conditions differ in whether a phrase boundary exists between the target word and the functor. To illustrate the syntactic structures of the two conditions in formal terms, the following representations using labeled bracketing are derived.

(7) a. $Shai_{V}$ le_{ASP} $tongji_{N}$
$[_{TP}$ *pro* $[_{vP}$ ***SHAI-le***$_{i}$ $[_{VP}$ t_{i} *tongji*$]]]$[1]

b. $Shai_{N}$ bu_{NEG} $tongji_{V}$
$[_{TP}$ ***SHAI***$_{i}$ $Ø_{pres}$ $[_{NegP}$ ***bu*** $[_{vP}$ t_{i} $[_{VP}$ *tongji*$]]]]$

As can be observed from the bracketings above, despite the linear adjacency between the target word and the function word in both cases, the two words are found in the same bracket in the *le* condition but are separated by a phrase boundary in the *bu* condition. The following figure demonstrates how elements are conjoined differently in the two structures (trace *t* is represented to indicate the hierarchy; a triangle indicates a VP).[2]

[1] Here, we use *SHAI-le* to indicate that the word is formed independently of syntax, though some other syntactic analyses might suggest otherwise (i.e. *le* lowers from Asp to V as a case of Affix Hopping, or V adjoins to *le* at *v* due to light verb attraction). According to Huang, Li, and Li (2009: 103-105), the concatenation of a verb and its inflectional affix is recognized as a word-formation rule independent of syntax, hence *V-le* as an integrated verb form (already merged in the lexicon) moves overtly from V to *v* (light verb), which produces the right word order, but at the level of LF (Logical Form), it continues to covertly move to Asp where aspect information is coded.

[2] The nodes are unspecified in the tree diagram for clearer display of the combinatorial structures.

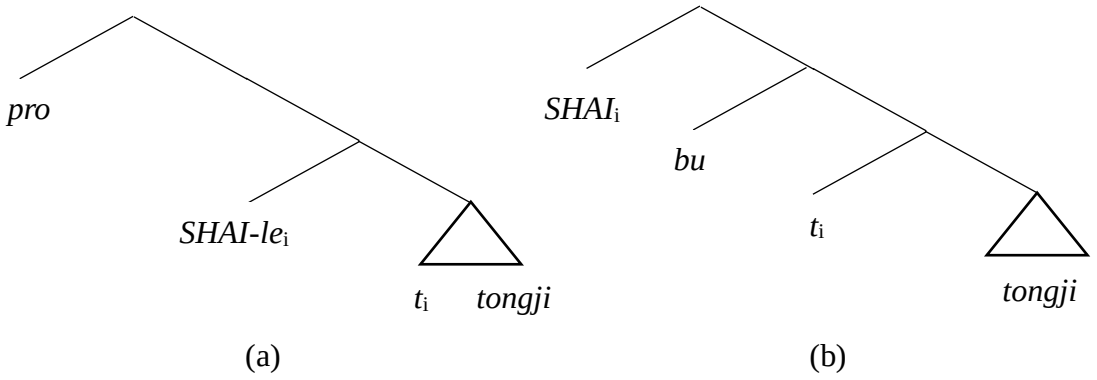

Figure 4.2 Configurations of the two functors in relation to the target words

Here, we spell out the difference between the two structures in detail. The perfective aspect marker *le*, according to formal analyses, eventually lands in v^0 in order to match itself with the node that bears information about the event (Huang, Li, & Li, 2009).[1] Based on this configuration, the target word *SHAI* finds itself under the same minimal projection v^0 with *le*, therefore the task in the *le* condition can be encapsulated as the syntactic labeling of the target word local to the functor. For the negation marker *bu*, however, the target word *SHAI* finds itself in a position outside the right-branching NegP (negation phrase), presumably incurring an increased processing burden for young children.[2] This cost of introducing the negation marker, a truth-functional logical operator, to an affirmative statement has already been confirmed in comprehension tasks with 2-year-olds, where toddlers by that age still have problems processing negative propositions from the ground up (Reuter, Feiman, & Snedeker, 2017). Besides, the rightward scope of negation expressed by the negation marker *bu* could also predispose toddlers to attend to the structure on its right while ignoring elements on the left, resulting in their failure to categorize the target word to the left of the negation marker.

In a follow-up study, we intended to build on findings from the current experiment by directly addressing whether toddlers' grammatical categorization of the target word could be facilitated if the labeling task is performed within the phrasal unit of the functor. Since 19-month-olds in the current experiment failed in using the negation marker *bu* to categorize a preceding noun, we used another noun predictor, the focus particle *ye*, to test

[1] According to a more recent analysis (cf. Sybesma, 2017), suffix *-le* is initially found at the head of inner aspect Asp^0 which is above VP but below *v*P. The verb first moves from V^0 to inner Asp^0 to combine with the suffix *-le* and then moves further to v^0.

[2] Such burden is also obvious, assuming that the target word undergoes movement in both structures. In (7b), *SHAI* as the subject, is coindexed with its trace *t* in the specifier of VP – it moves across the negator *bu* in NegP to the specifier of TP. However, in (7a), the landing site is below NegP and nothing intervenes between *SHAI-le* and its trace *t*.

if the target word can be categorized when it is within the phrase headed by the functor (i.e., [*X ye* [*Y*]]). Its cue validity is 0.003, given its cue availability (0.29%) and its cue reliability (92%) in the transcripts of Tong's corpora at the two ages of 19 and 20 months old in CHILDES (cf. Deng & Yip, 2018). As a common functor in input, the focus particle *ye* first emerges in child speech at around the age of 18 months (Fan & Song, 2013).

(8) *Shui* *ye* *tang*.
water FOC hot
"The water is also hot."

(SJQ, 1;5;28)[1]

For its identity, *ye* is termed in the literature as a 'backward-linking adverb' (Alleton, 1972) or 'focus adverb' (Li & Thompson, 1981), given its properties akin to those of adverbs like *also* or German *auch* (cf. Krifka, 1998; Reis & Rosengren, 1997). Besides, *ye* also becomes functionally close to *even* in English when it is phonologically reduced and serves as a semi-clitic particle.[2] In this case, the *even*-type *ye* is obligatorily preceded by a focused nominal phrase, as exemplified by (9).

(9) *Xiaoming* *ji-rou* *ye* *bu* *chi*.
Ming chicken-meat FOC NEG eat
"Ming doesn't even eat chicken."

A focused element (e.g., *ji-rou* "chicken meat") typically found in a post-verbal position (the object for instance) must move to the position left to the focus particle for focus-background agreement (cf. Constant & Gu, 2010; Hole, 2004). This structural contrast between the negation marker *bu* and the focus particle *ye* as noun predictors, therefore, would serve as a sensitive probe into the type of word co-occurrences that toddlers instinctively track for grammatical categorization – whether phrase boundaries create barriers for the classification of target words adjacent to functors.

[1] The age of production is noted in the format "year; month; day".
[2] The parametric use of *ye*, together with *cai*, *jiu*, and *dou*, fits into a systematic paradigm of different quantificational types in Mandarin. The marker *ye* is one that indicates existential quantification over alternatives.

Chapter 5 Follow-Up Study

5.1 Objectives

In our previous experiment, the frequent functor *bu*, the Mandarin negation marker, was chosen to see whether Mandarin-learning toddlers would show commitment to a distributionally typical structure; according to the findings, toddlers failed to use *bu* to categorize a preceding noun.

Our account for their failure in noun categorization is the obstruction of the phrase boundary between the target word and the succeeding function word. In a follow-up study, we therefore chose the focus particle *ye* to see if toddlers' grammatical categorization of the noun can be facilitated by a strict local structure (the noun preceding the focus particle *ye* as a part of the focus phrase). In brief, we address the following two questions:

(1) Are toddlers able to categorize the target word preceding the functor *ye* as a noun? Will toddlers show the same looking preference in the test phase for grammatical noun trials (contrary to grammatical verb trials for toddlers in the *le* condition)?

(2) Does a local structure (i.e., no phrase boundary between the target word and its succeeding functor) truly make a desirable work space for toddlers' grammatical categorization? If so, what should this tell us about early mechanisms toddlers harness for efficient morphosyntactic parsing?

5.2 Methodology

Participants. 12 monolingual, normally developing Mandarin infants (7 boys, 5 girls; *M* age = 19 months 14 days; range = 18 months 18 days to 20 months 25 days) living in Beijing participated in the study and were assigned to the *ye* condition.

Another 4 infants participated in the test but their data were eliminated from the final analysis due to fussiness (2), failure to stay on task (no recovery of looking time to the post-trial; 1), and mis-operation (1).

Stimuli. Similar to the previous experiment, the focus particle *ye* was embedded in a 3-word sequence *XaY* (*a* being the function word) to render the initial target word *X* and the final filler word *Y* both linearly adjacent to the functor. Target words for categorization were the same two monosyllabic words, namely *SHAI* and *MAN*.

The stimuli during familiarization were recorded by a native female Mandarin speaker. The target words in the *ye* condition were recorded with comparable phonological features to those of the *le* and *bu* conditions in the previous experiment, regarding duration, mean pitch, and mean intensity (for detailed prosodic values, see Table 5 in the Appendix).

Design. We adopted a design similar to the one specified in Chapter three. The table below describes the familiarization and test stimuli of the *ye* condition.

Table 5.1 Familiarization condition and test items in Experiment two

Familiarization (T_{max}=30 s, ISI = 1200 ms) ***ye* condition**
SHAI *ye* tongji MAN *ye* tongji MAN *ye* jianyan SHAI *ye* jianyan
Test (T_{max}=17.6 s, ISI = 1000 ms)
Trial 1 *shi zhege* SHAI *shi zhege* MAN
Trial 2 *dou keyi* SHAI *dou keyi* MAN
Post-test

Procedure. The procedure was similar to the previous design.

Predictions. This design should shed a light on children's early representations of different functional morphemes regarding their phrase structures. If infants have used the function word *ye* to categorize the target word during the familiarization phase, they were expected to show preferential looking to either grammatical test trials (familiarity effect) or ungrammatical ones (novelty effect). To be specific, if infants are sensitive to the phrase boundary of a given functor and are able to use such knowledge to constrain grammatical categorization, it is expected that toddlers will succeed in categorizing the target word with the focus particle *ye*, a functor that incorporates its preceding lexical element within its phrase boundary. Otherwise, they should show no distinction between

the two types of test trials; namely, there should be no significant difference between the average looking time during grammatical trials and that during ungrammatical ones.

5.3 Results

Toddlers' average looking times during the test trials in the *ye* condition were calculated and examined through paired *t*-tests. To better illustrate our findings in relation to what we have found in the *le* condition, we contrasted the results in Figure 5.1.

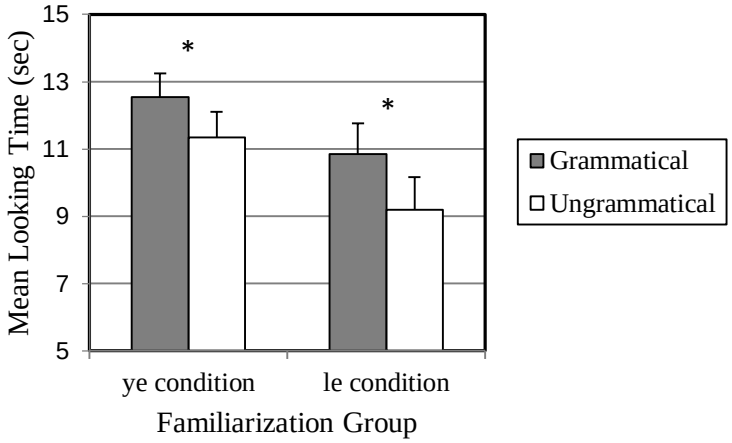

Figure 5.1 Mean looking times (and standard errors) during the two test trial types (grammatical vs. ungrammatical) for the *ye* condition (compared to the *le* condition)

Our paired *t*-tests show that toddlers familiarized with the *ye* condition showed clear distinction between the grammatical noun trials and the ungrammatical verb trials. Specifically, they looked significantly longer to the grammatical trials (M = 12.547 sec, SE = .702 sec) than to the ungrammatical trials (M = 11.349 sec, SE = .754 sec), $t(11) = 2.913$, $p = .014$. This indicates that toddlers have a strong preference for grammatical trials.

We also analyzed toddlers' data from both the *le* condition and the *ye* condition with a 2 x 2 ANOVA test, with Grammaticality presented as one within-subject factor (grammatical vs. ungrammatical) and Condition (the *ye* condition vs. the *le* condition) as the other between-subject factor. Our results show that there is no effect of Condition, $F(1,22) = 2.919$, $p = .102$, but a significant effect of Grammaticality, $F(1,22) = 13.428$, $p = .001$. This indicates toddlers' equal competence in using the focus particle *ye* for categorizing a preceding noun and the aspectual suffix *le* for categorizing a preceding verb. Further, the interaction between Grammaticality and Condition for all ten trials did

not approach significance, $F(1,22) = .342$, $p = .565$. These findings confirmed our prediction that toddlers are capable of exploiting functors to categorize an adjacent noun in a backward fashion when the bigram (the target word and its adjacent functor) forms a local phrasal unit. As can be observed from the previous figure, subjects in the *ye* condition showed a significant difference in their average looking times for the two types of test trials, and that they looked significantly longer to the screen during grammatical trials than during ungrammatical ones, suggesting a potential familiarity effect.

5.4 Discussion

In the follow-up study, toddlers demonstrated looking preference for the grammatical trials after being familiarized with sentences featuring the focus particle *ye* to be the utterance-medial function word. That is, they categorized the target word preceding *ye* as a noun during familiarization and listened significantly longer to grammatical trials presenting the target words in new noun contexts than to ungrammatical trials presenting the target words in new verb contexts.

Notice that the grammatical trials for the *le* condition and the *ye* condition were crossed, given that verb contexts are grammatical for the *le* condition, whereas for the *ye* condition, noun contexts are grammatical. However, instead of favoring a certain type of context in the test phase, subjects in both conditions showed evident preference for the corresponding grammatical trials, namely new verb contexts in the *le* condition and new noun contexts in the *ye* condition. This serves as a robust piece of evidence for toddlers' inclination to differentiate between functors in categorizing their adjacent novel words, thereby knowing what other syntactic environments these novel words can fit into. It is unlikely that their generalizations about the matching contexts for these target words were of a stochastic nature.

Furthermore, toddlers' successful categorization of the target words as a noun in the *ye* condition, instead of the *bu* condition, converges with the within-bounds account which predicts phrase boundary to be a potential barrier for backward categorization in context of bigram patterns. The fundamental difference between the *bu* condition and the *ye* condition lies in whether the preceding target word forms a cohesive unit with the adjacent function word. To bring to light the difference between the two structures regarding their respective function words, the label bracketings for the two conditions are presented below.

(10) a. *Shai*$_{N}$ *bu*$_{NEG}$ *tongji*$_{V}$
[$_{TP}$ ***SHAI***$_{i}$ Ø$_{pres}$ [$_{NegP}$ ***bu*** [$_{vP}$ t_{i} [$_{VP}$ *tongji*]]]]

b. *Shai*$_{N}$ *ye*$_{FOC}$ *tongji*$_{V}$
[$_{FocP}$ ***SHAI***$_{i}$ ***ye*** [$_{TP}$ t_{i} [$_{vP}$ t_{i} [$_{VP}$ *tongji*]]]] or
[$_{TP}$ *pro* [$_{FocP}$ ***SHAI***$_{i}$ ***ye*** [$_{VP}$ *tongji* t_{i}]]]

According to formal syntactic theories, the focus particle *ye*, when used as the English *even*, is defined as the functional head of the so-called Focus Phrase, or FocP (cf. Gao, 1994; Shyu, 1995), in which the focus particle (*ye* for instance) forms a syntactic unit with its preceding focused noun phrase. This, however, is not the case with the negation marker *bu* where the noun preceding *bu* lands in the specifier of TP (Tense phrase for encoding temporal-spatial information), a syntactic location outside the negation phrase.

It is also interesting to note that 19-month-olds in our experiments have demonstrated sensitivity to the focus particle *ye* in an utterance-medial position at an age when the particle has not yet entered their productive lexicon. Acquisition studies on early Mandarin-learning children's production of focus particles (Fan & Song, 2013) suggest that toddlers have not yet started to productively use the focus particle *ye* until the age of 22 months (marked by spontaneously using the same particle across at least three different sentence frames). Apart from this, it was also found that before 29 months of age, toddlers almost predominantly favor the use of *ye* in constructions where the subject, instead of the predicate, serves as the focus of the particle *ye*. This observation not only coincides with the current assumption, that the focus element and the focus particle share a close structural bond, but also bears out how these two syntactic objects are interconnected in toddlers' linguistic representation from early on.

Chapter 6 General Discussion

Adopting a Visual Fixation Procedure, we found that Mandarin-learning 19-month-olds can exploit an utterance-medial functional morpheme *a* in a 3-word sequence *XaY* to categorize the target word *X*. In the present study, toddlers were randomly familiarized with either the *le* condition featuring the aspect marker or the *bu* condition involving the negation marker, and their looking times during the test trials indicate that they only categorized the preceding target word to be a verb in the *le* condition but did not show clear signs of noun categorization in the *bu* condition. To examine if toddlers can categorize a preceding noun when it is local to the phrase headed by the succeeding functor, the focus particle *ye* was tested in a follow-up study, and our subjects succeeded in categorizing the preceding nouns. This study is the first to evince that Mandarin-learning toddlers are able to exploit utterance-medial functional morphemes in constraining syntactic analysis and categorizing adjacent lexical elements. We discuss in this section how these findings can be interpreted in relation to foregoing studies.

6.1 Processing Outruns Production: Capturing Utterance-Medial Functors

Toddlers as old as 19 months are capable of processing functional morphemes in utterance-medial positions; yet, their early representation of functors could be largely obscured by production data. For instance, our perceptual experiment has instantiated that Mandarin-learning toddlers already have syntactic representations of the verb suffix *-le* by 19 months of age, but if we closely examine their production data, only sentence-final *le* can be found at this age; they only start to produce suffix *-le* at around 24 months of age. Sentence (11a) is a case of sentence-final *le*, as it appears in the order 'VP + NP + *le*', while sentence (11b) is a case of verb suffix *-le*, given the word order of 'VP + *le* + NP' (Zhang & Wang, 2009).

(11) a. *you* *chi* *danhuang* *le*.
again eat egg yolk SFP
'I am eating egg yolk again this time.'

(CQF, 01;07;15)

b. *pen-le* *yi-bei* *shui*.
spurt-PERF one-CL water
'I spurted a cup of water.'

(LXY, 02;00;21)

Indeed, what we observe in the development of *le* constructions from the sentence-final *le* in (11a) to the suffix -*le* in (11b) is a great divide. During the interim, the truly competing *le* constructions are "VP + *le*" and "VP + NP + *le*" which complement each other consistently before 2 years of age; the use of suffix -*le*, however, seems to go along an independent path in production and is grossly disproportionate to the two types of sentence-final *le*, even after its first emergence in children's spontaneous production at around 1;11.[1] On the surface, this could easily be taken as another piece of cross-linguistic evidence for the unfledged representation of functional elements in early children, given that the absence of undisputed suffix -*le* in Mandarin-learning children's early production data mirrors the omission of person agreement by French-learning children (Legendre, Hagstrom, Vainikka, & Todorova, 2000) and the absence of tense marking by Catalan-learning children (Davidson & Legendre, 2001). Given these observations, previous studies conclude that for the same functional morpheme in different sentential positions, the sentence-final one often emerges earlier in children's production (e.g., Song, Sundara, & Demuth, 2009; Sundara, Demuth, & Kuhl, 2011). This finds echoes in the 'less is more' hypothesis by Newport (1990; also see Elman, 1993) suggesting that edges of utterances like the beginnings and the ends are privileged in language processing by children; by contrast, the audibility of auditory stimuli in utterance-medial positions is often reduced by their subsequent items (Moore, 1997).

[1] In fact, among the cases of 'VP + *le*' in toddlers' output, some can be easily mistaken as suffix -*le* due to the perfectivity they encode as a part of their meanings.

a. *Yangyang* *dakai* *le.*
Yangyang open PERF/SFP
'I, Yangyang, have opened (it).'

(SYY, 1;7;2)

b. *wanju* *diao* *le.*
toy fall PERF/SFP
'The toy fell.'

(a) is a clear case of elliptical expression in which the object following the transitive verb *dakai* 'open' is dropped; another case represented by (b) is when *le* follows an intransitive verb and naturally becomes sentence-final. The perfective reading in these two cases is essentially a spin-off from the sentence-final *le* in marking how the speaker perceives and remarks on the relevant state of affairs (e.g., anchoring a particular state or event) with reference to speech time (cf. Li & Thompson, 1981; Lu, 1980; Xia, 2017).

Presumably, this is partly attributable to the recall advantages of utterance-initial and utterance-final positions over utterance-medial positions (Sundara, 2018). Would this cognitive constraint eventually lead to infants' fragmentary representation of structures?

The present study captures a glimmer of infants' already existing, nevertheless underestimated sensitivity to theoretically disadvantaged utterance-medial positions. Specifically, after limited exposure to 3-word sequences with a shared embedded functional morpheme during a 30-second training session, Mandarin-learning 19-month-olds managed to perceive utterance-medial functional morphemes as a cue for categorizing their adjacent target words. It is therefore reasonable for us to question if it is necessarily the case that toddlers are unable to attend to items in the middle of a continuous speech; rather, toddlers' syntactic awareness of functional morphemes across sentential positions with respect to the underlying structures could have been underrated to a great extent. Given our findings, the absence of certain functional elements in Mandarin-learning toddlers' early output should be attributed to factors other than their unfledged syntactic representations.

Take the case of verb suffix *-le* as an example and we might identify several accounts for the absence of the morpheme in early production. One obvious account is the extremely low proportion of verb suffix *-le* in children's input (based on data in Hagstrom et al., 2001).[1] In average, suffix *-le* (9 tokens out of a total of 835 utterances) makes only 1.1 % of adult speech (note that the suffix *-le* by this count only includes cases where *le* precedes an object), whereas sentence-final *le* (213 tokens out of 835 utterances) constitutes 25.5% of the input, almost 24 times that of suffix *-le*. It is therefore unsurprising to us that children before age two failed to productively use the suffix *-le* (in fact, there was none by the stage they were investigated). The second possible account, following the idea promoted by Hagstrom et al. (2001), is that the absence of the suffix *-le* reflects toddlers' optimal resolutions to candidate output structures respecting their rankings of conflicting constraints under the framework of the Optimality Theory (see Prince & Smolensky, 1993, for details). What has been observed in the production of *le* is that, the structural markedness constraint that prohibits an additional structure (projected for utterance-medial aspect morphology) outranks the faithfulness constraint that calls for the overt realization of the [perfective] feature (i.e. the insertion of the suffix

[1] The analysis is based on the corpus of LXB, YY, and BB, three monolingual Mandarin-speaking children living in Beijing (CHILDES Database; Tardif, 1993, 1996).

-*le*). In consequence, this conceivably leads to toddlers' default setting for which sentence-final *le* is exploited as a close functional approximation for the suffix -*le*.[1] One more viable way to interpret toddlers' output is that toddlers' early production of *le* in sentence-final $V_{[t]}$-*le* is intended as the suffix -*le* ($V_{[t]}$ marks a transitive verb). This claim is reasonable if we scrutinize toddlers' elliptical expressions with respect to the ellipsis sites and the respective cost they entail. To illustrate the comparison between the two structures, we present the following analyses to examine the structural implications of *le* as a sentence-final particle and as a suffix.

(12) a. $[_{CP}\ [_{VP}\ V\ e]\ le]$[2]

b. $[_{vP}\ V\text{-}le\ [_{VP}\ e]]$

When the *le* in $V_{[t]}$-*le* is analyzed as the sentence-final *le* in (12a), the elided object (indicated by the variable *e*; cf. Huang, 1984) is embedded in the sentence (i.e., between the transitive verb and the sentence-final *le*), whereas for the alternative analysis of *le* as the suffix -*le* in (12b), the elided object is at the right edge of the sentence, a location where ellipsis is more commonly found in the language and intuitively less taxing. Based on such observations, it would not be too hard for us to notice that theoretically, considering both the deletion (for the phonetic form) and the reconstruction (for the logical form) of the elided object, (12b) demonstrably outperforms (12a) in terms of computational efficiency and presumably characterizes toddlers' $V_{[t]}$-*le* constructions at an earlier stage. This interpretation of toddlers' output structures is only tentatively assumed, given our findings concerning toddlers' early sensitivity to the suffix -*le*.

Furthermore, our study lends cross-linguistic support to the assumption that children exploit functional morphemes in different utterance positions long before their production as a means for uncovering the syntactic categories of neighboring lexical items and scaffolding semantic interpretation. Despite its low token frequency compared to the

[1] Though sentence-final *le* and verb suffix -*le* are often considered to be structurally contrasting, they overlap occasionally in terms of their functions. Conventionally, sentence-final *le* conveys informativeness as in suggesting something noticeable to coordinate common ground between the speaker and the hearer, whereas verb suffix -*le* serves to mark 'completion' in reporting a bounded event or connecting episodic events in sequence; yet, in scenarios where the verb suffix -*le* occurs in clause-final position, the morpheme *le* naturally takes on the informative flavor of sentence-final *le*, in addition to marking 'completion' (van den Berg & Wu, 2006).

[2] In line with the definition of the particle as modal particles in traditional theories, sentence-final *le* is treated as a category belonging to CP by most formal syntacticians (cf. Paul, 2014; Shi & Hu, 2006). Within the framework of split-CP hypothesis (cf. Rizzi, 1997), sentence-final *le* is further classified as the head of FinP (Finiteness phrase, which is at the level of lower CP embodying the interface between pragmatics and grammar) due to its hybrid function in combining both tense and mood (Zhuang, 2015).

sentence-final *le* in input (cf. Hagstrom et al., 2001), verb suffix *-le* has evolved into its own independent form in toddlers' syntactic representation at an early stage. This is in line with and also reliably prefigures Mandarin-learning children's later emerged finer-grained knowledge of perfective and imperfective aspectual morphology (Yang, Shi, & Xu, 2018; Zhou, Crain, & Zhan, 2014). Besides, infants' segmentation of verb suffix *-le* in the present study corroborates the morphological account for bootstrapping verbs (Behrend, Harris, & Cartwright, 1995; Marquis & Shi, 2015). With such mechanisms in place, it is very likely that child learners of Mandarin can buck the trend of noun bias and gain an edge in verb learning by accessing rich syntactic cues (Erbaugh, 1992; Tardif, 1996). Likewise, toddlers have already been able to perceive the focus particle *ye* prior to their spontaneous production and use it for locating a preceding nominal phrase – this, on top of what we have learned about the role of verb suffixes in bootstrapping verbs, offers a refreshing view on how functional morphemes bearing information-structural import can bootstrap nouns in a focused position. It is highly possible that semi-clitic focus particles, like the ones grammaticalized in Mandarin to quantify over focus alternatives as well as governing focus-background agreement, also constitute a functional category viable for noun categorization in other languages.[1] It is also worth noticing that toddlers' productive use of the focus particle *ye* only emerges after 22 months of age, whereas 19-month-olds in our present study have already started to use the particle for classifying its preceding noun. Moreover, their association of the focus particle *ye* to its left NP in our follow-up study is consistent with their later emerged production of *ye* constructions in which the subject NP left to the focus particle predominantly receives the focus for computing the contrastive set (Fan & Song, 2013).

[1] Focus-background agreement has been identified in a number of languages, one typical example of which is Yukagir, a Uralic language spoken along the Kolyma river. Different verbal markings are used in past tense sentences in Yukagir to distinguish subject focus, object focus, and verb focus (Hole, 2004).

a. ['What did you shoot?']
   met *ile-leŋ* *ai-meŋ*
   I deer-FOC shoot-OBJ.FOC/1S
   'I shot THE DEER.'
b. ['What did you do to the deer?']
   met *ile* *mer-ai-ŋ*
   I deer VERB.FOC-shoot-1S
   'I SHOT the deer.'

Unlike Yukagir, however, such agreement in Mandarin serves to specify different types of quantification over focus alternatives.

6.2 Filters for Distributional Information in Lexical Categorization

Aside from substantiating toddlers' sensitivity to utterance-medial function words during their processing of speech flow, the findings of this study provide fundamental insight into the nature of bigram contexts that toddlers readily exploit for grammatical categorization of lexical items with respect to two dimensions of regularities, namely those defined by the syntactic structure and by the phonological structure.

First, in harnessing the combinatorics of syntactic units, toddlers are biased to categorize a target word when it is local to a phrase headed by a functional morpheme. To put it differently, distributional contexts local to functional morphemes are prioritized as windows for lexical categorization. In our particular study, Mandarin-learning toddlers' categorization of verbs in "verb + suffix" and of nouns in "noun + focus particle" but not of nouns in "noun + negation" strongly supports what has been concluded from distributional analyses concerning effective cues for discerning syntactic categories. These findings are in line with the type of distributional information that several studies have suggested to be useful for the acquisition of syntax. According to several measures looking at the informativeness of different contexts for grammatical categorization, a bigram context has been found to serve most efficiently when it is restricted to a local phrasal unit, meaning that the target word and the functional morpheme in the bigram are undivided by a phrase boundary (Mintz, Newport, & Bever, 2002). Another motivation to look at bigram contexts is that during the first stages of identifying syntactic categories, children's narrow window for grammatical analysis as well as their limited vocabulary to connect the dots prompts them to look for smaller and hence more restrictive windows for distributional information. Essentially, this would result in children's categorization mechanisms to be functioning in a way that avoids 'unnecessarily complex computation' (cf. Redington, Chater, & Finch, 1998: 436); in other words, not every word in a child's input can be assigned a syntactic category. This proposed tendency also finds support from foregoing studies on grammatical categorization by infants learning Indo-European languages. Specifically, bigram patterns represented by "determiner + noun" ([$_{DP}$ Det N]) have been shown to effectively support grammatical categorization of nouns by 14- and 16-month-olds, whereas the other pattern featuring "pronoun + verb" ([$_{DP}$ Pron] [$_{VP}$ V]) did not lead to robust grammatical categorization of verbs (Höhle et al., 2004; Shi & Melançon, 2010). Indeed, a later study by Cauvet et al. (2014) bears testament to phrase boundaries as a developmental hurdle to overcome, indicating that 18-month-old French-

learning toddlers, four months after they failed in using pronouns for verb categorization at 14 months of age, were eventually able to categorize verbs when exposed to bigram patterns of "pronoun + verb". Tentatively, we assume that toddlers' intuition for selecting windows for distributional analyses also meets computational efficiency from the perspective of generative syntax, given that they could be building preliminary syntactic structures through local merge, the joining of two elements into a smallest phrase (Chomsky, 1995). Such an operation is category-neutral in merging lexical materials into syntactic derivations in the sense that the derivations of noun phrases (NPs) and verb phrases (VPs) are equally possible upon the identification of a functor within the very phrase – based on the list of functional morphemes already examined across varied studies, determiners in the preceding context can be regarded as an early bootstrapper for noun labeling, whereas verb suffixes in the succeeding context (Mandarin aspect marker *le* for instance) presumably facilitate verb labeling.

Second, regarding the perceptual side of grammatical categorization, the syllabic structure of the functional morpheme itself, together with the prosodic structure of the bigram context, can directly impact the difficulty of extracting functional morphemes from bigram co-occurrences as well as producing them and whether such morphemes can be readily identifiable for categorizing immediately preceding or succeeding lexical items. Regarding the syllabic structure of the functional morpheme, bound morphemes that are syllabic, or can be analyzed as CV, VC, or V (C = consonant; V = vowel), can facilitate morphemic segmentation at an early stage (Brown, 1973: 107-109). Previous studies give evidence to the representation of the English *-ing* in 15-month-olds, the segmentation of French verb suffix (for past participle) *-é* in 11-month-olds, and the insertion of Italian inflectional endings for personal agreement *-o, -i, -a, -amo, -ate, -ano* in earliest production data from 20-month-olds (Guasti, 1994; Marquis & Shi, 2012; Mintz, 2013). In like manner, the present study provides proof for Mandarin-learning toddlers' ability to segment and identify the Mandarin verb suffix *-le* in a continuous speech flow. By contrast, a recent experiment suggests that when the English asyllabic third person singular morpheme *-s* is supposed to occur in an utterance-medial position (e.g., *He sleeps now* vs. *He sleep now*), 22-month-old English-learning toddlers cannot distinguish between sentences with or without the agreement morpheme (Sundara, 2018). The same constraints are also obtained with speakers with specific language impairment (SLI) – specifically, Italian- and Hebrew-speaking children with SLI are able to produce syllabic

inflectional endings with both verbs and nouns, whereas their English-speaking counterparts fail to add asyllabic inflections to verb stems in speech (Leonard, 1998). Regarding the prosodic structure, it is also likely that in a language like Mandarin, the typical strong-weak prosodic contrast between a lexical item and a functor may have facilitated toddlers' identification of suffixes or suffix-like elements along with their neighboring lexical items in continuous speech (Hung & Ann, 1997). That is, Mandarin functional morphemes like suffixes, aspect markers, and particles are mostly unstressed and relatively short in duration so as to be attached to their preceding stressed lexical morphemes (cf. Shen, 1990; Shi, 2006). Given such observations, it is worth considering whether toddlers' failure to use the unstressed negation marker *bu* in *X bu Y* for categorization could be partially attributed to the possibility that the negation marker *bu* failed to trigger its corresponding structure in toddlers in our experiment presumably due to the fact that its weakened acoustic property in our familiarization sentences not only eclipsed its structural independence from its preceding lexical item ([$_{NP}$ *X*] [$_{NegP}$ *bu* [$_{VP}$ *Y*]]) but also belied its semantic weight as a truth-functional logic operator.

6.3 General Implications for Toddlers' Categorization Mechanisms

In view of a bootstrapping approach to the acquisition of grammatical categories, how toddlers eventually manage to categorize lexical items boils down to two major tasks, namely parsing and linking.

For the task of morphosyntactic parsing, toddlers identify units of expressions in input by harnessing both prosodic-functor bootstrapping and combinatorial variations. To start with, prosodic-functor bootstrapping allows toddlers to break individual utterances down into major units, commonly the subject and the verbal predicate, for the division of preliminary search spaces and at the same time to target syntactic units with familiar functional morphemes (Gerken, Landau, & Remez, 1990; Jusczyk et al., 1992). Apart from this, the abundancy of combinatorial variations in input also provides infants with potential clues concerning which elements are inseparable across syntactic contexts as a source for and also approach to incidental learning of phrase structures. For theorizing how infants attune themselves to their mother tongue at the initial stage, previous studies have formalized distributional models (e.g., transitional probability) and demonstrated potential working mechanisms for capturing clusters of co-occurring sounds for word segmentation (cf. Saffran, Aslin, & Newport, 1996). With initial segmentation in place,

infants begin to zoom out to obtain a broader view on larger units like phrases or combinations of phrases. Specifically, early identification of phrasal units can be facilitated by movements, for which certain indivisible elements are fronted in sentences, and by omission or ellipsis, due to which full sentences are naturally reduced to shorter, structurally independent phrases. In the case of Mandarin for instance, the phrase boundary between the subject noun phrase and the negation phrase can be prominent to toddlers, given their exposure to the large proportion of null-subject sentences in input; that is, the subjects of sentences, unlike those made obligatory in English and French, are massively dropped when they are established in the specific discourse context or topic chain (Hyam, 2011; Wang, Lillo-Martin, Best, & Levitt, 1992). Along these lines, toddlers could become increasingly aware of phrasal units in input and perceive that a function word like the negation marker *bu* only necessitates a local element on its right but not on its left, a fact which might lead toddlers to decouple the negation marker *bu* from its preceding word on a probabilistic basis.

Another work essential to toddlers' categorization is the linking between functional morphemes and the neighboring content words they syntactically specify. To do so, toddlers have to look at the front edge of phrases for a potential anchor, namely the functional morpheme, and forge a bond between the functional morpheme and its adjacent lexical item based on their bigram co-occurrences. Based on a homogeneous group of familiar content words that co-occur with the same functional morpheme, toddlers are then able to assign a reliable syntactic category to the lexical slot adjacent to the specific functional morpheme, and conversely, the functional morpheme itself would be marked in infants' functional lexicon as a reliable predictor for the syntactic category of its lexical neighbor. These functional morphemes as predictors for grammatical categorization include both free morphemes and bound morphemes. In our particular study, the suffix -*le*, as a bound morpheme, has been proved to be a reliable morphological cue for identifying the syntactic class of verbs (cf. Maratsos, 1988); the focus particle *ye*, as a free morpheme for computing and contrasting alternatives, also plays a role in pinpointing the syntactic class of nouns. Such a distributional approach that picks out pairs of highly local lexical items and functors has indeed been substantiated by corpus studies examining the feasibility of such cues in child-directed speech (e.g., Redington et al., 1998).

In general, the critical role of functional morphemes for toddlers' categorization

mechanisms can be elucidated with reference to the configurational description of functional categories in formal theories. Particularly, the projections of functional categories form a critical basis for encoding inflections and scope-discourse properties by offering 'landing sites' for displaced, mostly bare elements of nouns and verbs and hence deriving the linear order of inflected sentences.[1] In this sense, the role of functional morphemes in localizing lexical elements is essential across different stages of language development.[2] For infants in particular, by perceiving these reliable 'localizers', they are able to derive knowledge of phrase structures from scratch, which accounts for why they seem to be inclined to analyze the syntactic category of a novel word when it occurs within the phrase edge marked by a familiar functional morpheme.

6.4 Open Questions: Special Case of Negation

Whilst the abovementioned findings have contributed to the study of grammatical categorization in early language acquisition, some unresolved puzzles are also apparent in the present study. Specifically, though the within-bounds account we proposed for grammatical categorization is capable of clarifying a broad range of data, including the three conditions examined in this study and foregoing studies concerning grammatical categorization, it would be unjustifiable to draw the hasty conclusion that 19-month-olds are unable to analyze the structures left to a negation phrase. Instead, we sketch the following alternative possibilities for why they failed to categorize the target word after being familiarized with the negation marker *bu*.

One possibility is that toddlers in the *bu* condition might find it hard to access the negation marker *bu* due to its below-par prosodic significance in triggering the target structure. Notice that the negation marker *bu* in our familiarization sentences is acoustically reduced (to control for its acoustic difference from that of the suffix *-le*) hence prosodically adjoined to its preceding word. Consequently, this could potentially

[1] The fundamental functional categories include Complementizers (CP), Inflections (IP), and Determiners (DP). Specifically, CP concerns the clausal functional projections encoding scope-discourse properties like topic, focus, and questions; IP locates clausal functional projections for elements like mood, tense, negation, aspect, and voice; DP specifies the referential property of nouns with elements like definiteness, number, adjective, and agreement (cf. Rizzi & Cinque, 2016).

[2] Indeed, the significance of functional categories has been verified in experimental works with adult sentence processing. On the one hand, adults with normal language development are greatly assisted by these functional elements in learning an artificial language (e.g, Morgan & Newport, 1981; Valian & Coulson, 1988) and show brain responses (e.g., *N400-700*, or *BNS*) in anticipating beginnings of phrases and sentences cued by function words (e.g., Brown, Hagoort, & ter Keurs, 1999; Van Petten & Kutas, 1991); on the other hand, agrammatic populations manifest an impaired production of functional categories but maintain relatively intact lexical categories (e.g., Friedmann, 2006).

undermine its expected stressedness, despite the typicality of the structure in which a noun precedes the negation marker *bu*.

Second, it is unclear whether toddlers' failure in using the negation marker *bu* for noun categorization is due to the difficulty of parsing the negation marker in our experiment, as they were only exposed to negative sentences during familiarization. This potential difficulty with parsing all negative sentences has been noted in a recent study looking at English-learning 2-year-olds' comprehension of the negation marker *not* (Reuter et al., 2017). In this study, two groups of subjects heard blocked trials of affirmative and negative statements in a comprehension task; for the first group, subjects first heard the affirmative statements and then the negative statements, while for the second group, the order of the blocks was reversed. The results show that the subjects failed in comprehending either statements when negative statements were presented prior to affirmative statements, but they succeeded in interpreting both types of statements when affirmative statements were first presented as a kind of structural priming for their succeeding negative counterparts. In view of the parsing difficulty with the negation marker, it is possible that subjects' performance in the present study might be enhanced in categorizing nouns preceding the negation marker *bu* if they were first familiarized with affirmative statements without *bu* (e.g., *XY*) and then negative statements with *bu* (e.g., *X bu Y*).

In brief, the experimental result with the negation marker *bu* is relatively more complicated, and to fully interpret our data concerning toddlers' early parsing of structures preceding the negation marker, further study is required to investigate the two possibilities mentioned above.

Chapter 7 Conclusion

The present study addresses the role of functional morphemes for toddlers' parsing of sentences and assignment of syntactic categories under the framework of the prosodic-functor bootstrapping hypothesis. By adopting a Visual Fixation Procedure, we investigated whether Mandarin-learning 19-month-olds can perceive and exploit the limited morphosyntactic cue of a common utterance-medial functional morpheme *a* to compute the structure of a continuous 3-word sequence *XaY* and classify the target word *X* preceding the functor *a*. To explore the characteristics of toddlers' underlying mechanisms for morphosyntactic parsing and grammatical categorization, we first examined the two conditions of the perfective marker *-le* and the negation marker *bu* and then tested the new condition of the focus particle *ye* in a follow-up study.

Our findings suggest that Mandarin-learning 19-month-olds are able to perceive utterance-medial functional morphemes and categorize their preceding target words. They succeeded in using the perfective marker *le* to categorize its preceding verb and the focus particle *ye* to categorize its preceding noun, but they failed to use the negation marker *bu* to categorize its preceding noun. Specifically, toddlers who were familiarized with the *le* condition looked significantly longer to grammatical trials presenting the target words as verbs than to ungrammatical trials presenting the target words as nouns. Such a pattern of looking preference for the corresponding grammatical trials was also observed in the *ye* condition, but for the *bu* condition, toddlers did not show distinction between grammatical and ungrammatical trials in terms of their average looking time.

In addressing the uneven outcomes observed in grammatical categorization, the interference account alone could not explain our experimental data. According to our corpus analysis of early infant-directed speech, structurally plausible exceptions are insufficient to compete with the noun-indicative *bu*; they do not qualify as toddlers' productive knowledge, either. A more justified account is that toddlers only backtrack to label the target word when it occurred in the same syntactic unit with the functional morpheme, as is the case with either [$_{vP}$ V-*le* […]] or [$_{FocP}$ N *ye* […]]; otherwise, their labeling of the target word could be hampered by an intervening phrase boundary, given toddlers' failure in the *bu* condition with [$_{TP}$ N [$_{NegP}$ *bu* […]]]. This within-bounds account also accords with findings from foregoing parallel studies.

In general, our findings shed new light on the representation of functional morphemes in infancy, the features that infants' parsing system embodies, and the implications for the general mechanisms underlying lexical categorization. First, regarding structures with utterance-medial functional morphemes, toddlers' processing capacity outruns their production; essentially, the production data at an early stage largely belie toddlers' early representations of functional elements. Second, in narrowing down the search space for functional "anchors" and ramping up the validity of grammatical categorization, toddlers are prone to prioritize syllabic, prosodically contrasting functional elements for speech segmentation as a starting point for approaching the syntax-semantics interface of functional categories; in addition, they prefer a phrase-based approach to parsing, by which syntactic categories are assigned to lexical neighbors within phrase boundaries of functors. Third, toddlers pursue multiple approaches to disclosing the syntactic categories of uninterpretable lexical elements, including tracking combinatorial variations in linguistic input at the level of macrostructure and linking lexical elements to locally interactive functional categories at the level of microstructure.

Could functional categories be the defining source of linguistic gravity that keeps lexical items in their orbits and sentences in order? The answer is yet to be revealed.

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Appendix

Table 3. Average acoustic values (and standard deviations) of the stimuli across multiple exemplars

Acoustic Measure	Mean for Noun Uses (*bu*)	Mean for Verb Uses (*le*)	*p* (One-way ANOVA)
Total utterance duration (sec)	1.255 (.096)	1.256 (.051)	.975
TW duration (sec)	.383 (.046)	.396 (.071)	.680
TW vowel duration (sec)	.165 (.015)	.171 (.027)	.579
TW vowel mean pitch (Hz)	181.202 (31.778)	204.050 (12.513)	.069
TW vowel mean intensity (dB)	84.966 (.893)	84.400 (.460)	.133
FW duration (sec)	.130 (.014)	.137 (.009)	.259
FW mean pitch (Hz)	180.470 (16.042)	184.713 (17.353)	.619
FW mean intensity (dB)	84.991 (2.035)	83.993 (.784)	.217

Table 5. Average acoustic values (and standard deviations) of the stimulli across multiple exemplars

Acoustic Measure	Mean for Noun Uses (*ye*)	Mean for Verb Uses (*le*)	*p* (One-way ANOVA)
Total utterance duration (sec)	1.267 (.049)	1.256 (.051)	.662
TW duration (sec)	.372 (.070)	.396 (.071)	.514
TW vowel duration (sec)	.171 (.015)	.171 (.027)	.964
TW vowel mean pitch (Hz)	181.672 (32.973)	204.050 (12.513)	.094
TW vowel mean intensity (dB)	84.680 (.588)	84.400 (.460)	.306
FW duration (sec)	.143 (.009)	.137 (.009)	.168
FW mean pitch (Hz)	182.502 (26.273)	184.713 (17.353)	.845
FW mean intensity (dB)	83.387 (1.206)	83.993 (.784)	.254

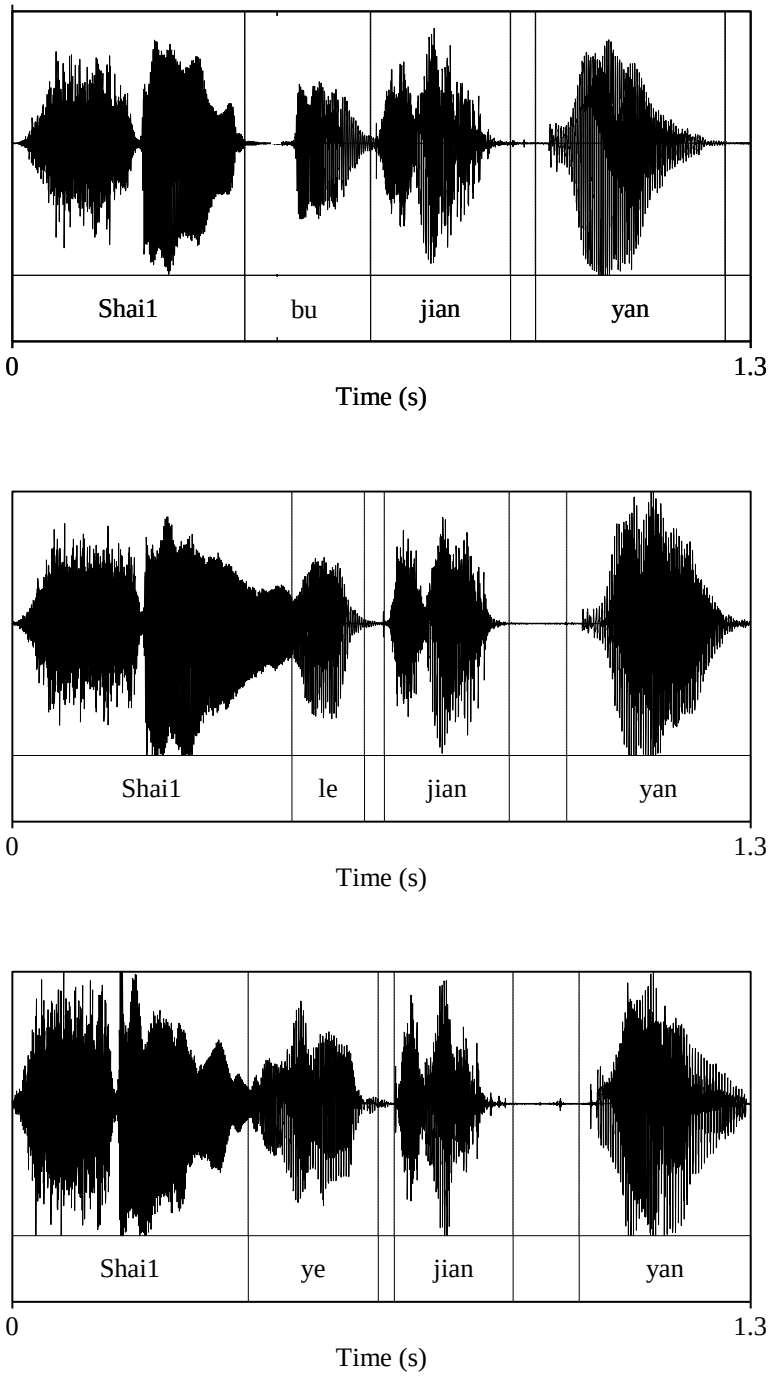

Figure 3. The waveforms and transcriptions of all stimuli during familiarization phase.

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声 明

本人郑重声明：所呈交的学位论文，是本人在导师指导下，独立进行研究工作所取得的成果。尽我所知，除文中已经注明引用的内容外，本学位论文的研究成果不包含任何他人享有著作权的内容。对本论文所涉及的研究工作做出贡献的其他个人和集体，均已在文中以明确方式标明。

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个人简历、在学期间发表的学术论文与研究成果

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