From Lexical to Functional Categories:
New Foundations for the Study of Language Development

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1. Introduction

We will use the term *Functional Categories* (FCs) in this article in contrast to the term *Lexical Categories* (LCs) to capture a distinction between the nouns, verbs and adjectives (LCs) exemplified in (1) below versus the underlined determiners (*the*, *an*), the verb phrase markers (the auxiliary *will* and the morphological verb inflection *-s*), the preposition (*with*), and the complementizer (*that*) – all of which constitute FCs in this sentence.

(1) The young girl will eat an ice cream that her friend shares with her.

All natural languages appear to distinguish FCs and LCs (e.g., Abney, 1987; Chomsky, 1995), and FCs, as a fundamental part of syntax, are thought to be unique to human languages (Hauser, Barner, & O'Donnell, 2007, p. 111). In general, FCs are assumed to carry major grammatical weight in sentence construction, whereas the LCs are assumed to carry major semantic force. However, we must recognize the difficulty in making this distinction. For example, even FCs may carry semantic relevance, and some units appear to be mixed, that is, the small class of pronouns such as *her* in (1) above which involves limited semantic factors such as gender, and plays a functional role in determining phrase structure. In addition, FCs vary across languages in their range and nature. In spite of the fact that FCs are often viewed as representing a small, closed class word category, it is now recognized that "the number of functional elements in syntax is not easy to estimate... but at the same time…100 would be a low estimate for English" alone (Kayne, 2005, p. 14). At the same time, even LCs such as noun, verb, and adjective are not easily categorized within and across languages (Baker, 2003).

Each of the linguist's challenges with regard to the definition and representation of FCs also confronts the child acquiring his/her language. The term *FC* implicates

several dimensions of language knowledge. The child must access (a) the word or morpheme which may overtly reflect the FC, e.g., as a Function Word (FW) or Function Affix (FA); (b) the abstract structure which underlies the FC; and (c) the role of the FC in grammatical computation (See Muysken, 2008, for a review). Critically, to acquire their language, the child must not only access FCs, but also recognize the crucial roles that FCs play in grammatical organization. For example, FCs provide a foundation not only for constituent segmentation but also for the skeletal architecture which underlies sentences, e.g., phrase structure, famously illustrated in Lewis Carroll's "Jabberwocky": "Twas brillig, and the slithy toves did gyre and gimble in the wabe" (Carroll, 1964, p. 15). Thus, Determiners (DET) head noun phrases, Inflectional elements (INFL) head verb phrases, and Complementizers (COMP) head clause structures. Linguists have argued that these provide targets for movement, agreement, and parametric operations in grammar (e.g., Galasso, 2016).

Since initial work in the field of language acquisition, scholars have noted that FWs often appear to be missing or to occur only variably at early periods of children's productive language (e.g., Bowerman, 1973; Braine, 1963; Brown, 1973; Gregoire, 1937). Various theoretical interpretations of these early productions have been proposed, for example (biological) brain maturation (e.g., Radford, 1990, 1997), or general (i.e., not language-specific) learning mechanisms (e.g., Tomasello, 2000a, 2000b, 2002).

More generally, the impoverished, inconsistent occurrence of FWs in children's early productions has led to what became the prevailing view in the field, that of a deficit in relation to early grammar, and of a pre-syntactic stage of development. Thus, it has often been assumed that young children (i.e., until about 30-36 months of age), are unable to encode FWs, and unable to recognize the grammatical role that FWs carry in sentences. Children in the early periods of language development have been thought to access (mainly) content words (CWs) such as nouns and verbs, and on the basis of these, to infer meaning and reference in other speakers' speech, and eventually build grammar (e.g., Grimshaw, 1981; Macnamara, 1982; Pinker, 1984).

However, this traditional view is now being challenged. In the last decades, advances in methodologies have allowed researchers to go beyond naturalistic studies of speech production in order to evaluate the child's access and use of FCs. Experimental

studies of discrimination, production, and comprehension in infancy and beyond, exploit a wide range of behavioral techniques such as High Amplitude Sucking, Intermodal Preferential Looking, Head Turn Preference, as well as neurophysiological (i.e., Event-Related Potentials - ERP) techniques. These, as well as advances in techniques for natural speech analysis, have made it possible to evaluate language more fully with regard to FC development, from the earliest periods, even from birth. Below we highlight discoveries from these studies, which suggest a precocious sensitivity to FCs and suggest a role for FCs in bootstrapping linguistic knowledge. While we will assume that "functional elements can and should be viewed as multidimensional" (Muysken, 2008, p. 5), we will here consider highlights from existing literature in the study of child language which implicate the role these elements play in early sentence organization and computation, thus focusing on their critical 'functional' characteristics.

2. Infants and FCs

(i) A precocious sensitivity

A considerable body of research now indicates that already before their first birthday, infants are able to: discriminate FWs from CWs and may do so in a categorical manner, demonstrated in infants even a few days old (e.g., Shi, Werker, & Morgan, 1999); discriminate and prefer well-formed FWs over nonsense FWs, thus demonstrating refined access of FWs (Hallé, Durand & de Boysson-Bardies, 2008; Shady, 1996; Shi, Cutler, Werker, & Cruickshank, 2006; Shi, Werker, & Cutler, 2006); and segment FWs from continuous speech and thus begin to encode some FW (Höhle & Weissenborn, 2003; Shafer, Shucard, Shucard, & Gerken, 1998; Shi & Gauthier, 2005).

In a seminal study by Shi, Werker, and Morgan (1999), newborns (1 to 3 days old) were presented with lists of FWs and CWs prepared from maternal speech samples, adopting a High Amplitude Sucking task. To examine whether infant access of FWs and of a FW-CW distinction, if present, is universal - newborns whose mothers spoke only English were compared with newborns whose mothers primarily spoke other languages. After being habituated to one list of tokens (either functional or lexical), the newborns were tested on novel lists of tokens: Newborns in the experimental group were tested on a list of tokens from an opposite category, while newborns in the control group heard novel

tokens but from the same category. Within the experimental group, presenting a list of tokens from a category that was different from the one the infants were habituated to yielded a significant recovery from habituation (i.e., dishabituation), reflected in a change in their sucking patterns (which occurred in the transition from FWs to CWs as well as from CWs to FWs). However, no such significant changes were recorded in the control group, where infants heard novel tokens taken from the same word category they were presented with in the habituation phase. Similar findings were reported in additional studies. French-acquiring 6-month-olds were found to distinguish CWs from FWs (Shi & Werker, 2001). In a Head Turn Preference task, 10.5-month-old infants listened significantly longer to passages with real FWs than to ones with nonsense items as substitutes for the FWs, even in a condition in which the nonsense words resembled real English FWs phonetically (Shady, Jusczyk, & Gerken, 1998). In an ERP study with 10- and 11-month-olds, infants heard both a modified and an unmodified version of a story – one with nonsense FWs, the other with English FWs. The 11-month-old infants (although not the 10-month-olds) significantly differentiated the modified and the unmodified conditions; allocating more attention to the modified rather than the unmodified version of the story (Shafer et al., 1998).

Infants have shown early access not only to FW, but also to sub-lexical functional items and morphological variations underlying inflection. For example, 11-month-old French-acquiring infants showed through an Intermodal Preferential Looking procedure that they treated verb root forms and inflected forms (root plus suffix) as related, even when tested with artificial verb root forms and/or artificial suffixes (Marquis & Shi, 2012). In contrast, infants treated non-inflectional words that overlapped with part of larger words as unrelated. Similar findings have been reported for English-acquiring infants and Japanese-acquiring infants (Mintz, 2013; Haryu & Kajikawa, 2016). When a set of bound FA are successfully encoded and accessed, the infant can relate and categorize different combinations of [root + bound morphemes] (e.g., *jump, jumped, jumping*) as one category on a morphological basis, without need to rely on word meaning (still underdeveloped in the young infant).

These early abilities to access FCs provide significant foundations for grammatical acquisition. As we review in the following sections, a wide body of research

now indicates that infants not only discriminate FWs but also actually consult FWs for grammatical construction. They use FWs to segment the speech stream, to assign lexical items to syntactic categories, to compute sentential relations, to parse the linguistic stimulus online, and to compute semantic reference.

(ii) Utilizing FWs to segment the speech stream

Research has documented that infants (from as early as 8 months of age) use FWs to segment the speech stream. For example, 8- to 11-month-old French-learning infants demonstrated that they are able use FWs to segment adjacent CWs. Infants were first presented a determiner preceding a novel noun versus a nonsense syllable preceding another noun. Infants were then tested with the nouns in isolation. Results showed that they preferred the noun from the determiner context, suggesting that the determiner assisted the segmentation of the adjacent word (Shi & Lepage, 2008). English-learning infants showed a similar result pattern (Shi et al., 2006). In another study, 11-month-olds have been shown to use their knowledge of FA (e.g., *-/e/* in French) to segment lexical word roots (Marquis & Shi, 2012). In Japanese, where noun-marking particles occur after nouns, the particle being a bound morpheme (e.g., *neko-ga* 'cat-subject marker'), 15-month-olds used this particle to segment the preceding noun from speech passages (Haryu & Kajikawa, 2016).

(iii) Consulting FCs to assign novel CWs to syntactic categories

By 12 to 18 months of age, lexical access is speeded and it is more accurate when known nouns and verbs are preceded by a FW from an appropriate category (e.g., determiners and pronouns, respectively, Kedar, Casasola, & Lust, 2006; Kedar, Casasola, Lust, & Parmet, 2017; Cauvet et al., 2014; Zangl & Fernald, 2007). This suggests that early on, even before the child actually utters even a single FW in production, the presence of a FW can assist their inference regarding the word class of the subsequent item. Accordingly, infants as early as 14 months of age begin to use FWs in syntactic categorization of lexical elements. English-, French- and German-learning infants have been shown to begin to use determiners not only to segment novel noun forms, but also to establish noun categories. Infants are capable of inferring the syntactic category of a

novel word after exposure to a co-occurring FW. By 14-16 months of age, German- and French-learning infants can determine that a novel CW following one determiner can also follow other determiners, but cannot follow pronouns (Höhle et al., 2004; Shi & Melançon, 2010). For example, infants were first familiarized with two strings consisting of a German determiner followed by a novel (nonsense) word: *ein glamm*, *ein pronk* (‘a glam,’ ‘a pronk’) and then tested on passages wherein the novel CW was used ether in noun phrase contexts such as *das Glamm* (‘the glamm’), *den armen Pronk* (‘the poor pronk’), or where the novel CW appeared in verb phrase contexts such as *Der Junge glamm* (‘the boy glammed’), *Manchmal pronk der Förster* (‘Sometimes pronk(ed) the ranger’). The FWs in the test phase were distinct from those in the familiarization phase and infants therefore had to rely on familiarity with the functional category of Determiners to categorize the novel word as a noun rather than simply memorizing a specific [FW-CW] combination. Infants had significantly longer average listening times for the verb passages than for the noun passages, suggesting reliance on the fact that a determiner preceded a novel word to categorize the novel word as a noun. This indicates that already at 14 months children may be able to extend the category information related to a specific syntactic context in which a novel word appears into other instances of the same syntactic class (Höhle et al., 2004, cf. Peterson-Hicks, 2006, for a similar design with 15-month-old English-learning infants). Further cross-linguistic evidence is provided by Zhang, Shi, & Li (2015) who report a significant discrimination of grammatical versus ungrammatical test trials based on FC in Mandarin-learning 12-month-old infants, although only in later stages of the test phase.

(iv) Using FCs to compute relationships within sentences

If FCs are significantly involved in the child’s grammar construction, it would be necessary that children integrate their representation of FCs in their representation of a sentence. Grammatically, FCs must function not only with regard to adjacent, but also non-adjacent dependencies within a sentence; as in agreement relations for example. In the next sections we review numerous studies which now provide such evidence.

In a Head Turn Preference study, 18-month-old French-learning infants were trained to turn their head to known words, either a noun (e.g., *Une balle* ‘a ball’) or a verb

(e.g., *il mange* 'he eats'), and then tested with these words used either grammatically or ungrammatically in sentence contexts, e.g., *la balle est rouge et verte* ('the ball is red and green'), or *je balle une petite pomme* ('I ball a small apple'). Infants discriminated and preferred grammatical sentences, where the target word appeared in a syntactically appropriate context, demonstrating an integration of FCs and sentential context (Cauvet, Limissuri, Millotte, Margules & Christophe, 2010). In another study, French-learning toddlers between 17 and 24 months of age demonstrated abstract sentence-based computation involved in their access and use of FCs (Massicotte-Laforge & Shi, 2015). 20-month-old infants were familiarized with either *crale* as NP [[*Ton felli* ***crale***][*vure la gosine*]] or as verb phrase [[*Ton felli*][***crale*** *vure la gosine*]], depending only on the syntactic and prosodic analysis in the examples (all words except the determiners are nonsense forms). Infants discriminated trials with *crale*, as a noun or a verb, e.g., *le crale* versus *tu crales*, preferring the noun version if they had been familiarized with the NP syntactic structure, but the verb, if familiarized with the VP structure. Moreover, they categorized different determiners as related, such as in *ton felli* in familiarization and the subject pronoun *tu* in the test, processing a non-adjacent relation between DET and noun. In a verbal inflection task using the Headturn Preference Procedure, 10.5-month-old infants distinguished paragraphs in which real (i.e., English) or nonsense FWs had been switched or substituted, versus a control paragraph in which FWs were in grammatical positions. Infants preferred the paragraphs that used real FWs and the correct grammatical order by 16 months, suggesting that infants were integrating FCs with sentential order (Shady, 1996). In another study with a similar Headturn Preference Procedure, 16-month-olds were tested in four experiments on a set of English sentences. In grammatical sentences, both word order and the inflectional properties of common nouns and verbs were in place. In contrast, ungrammatical sentences presented misplaced inflection and word order reversal of nouns and verbs. Infants detected the ungrammaticality when listening to sentences in which both CWs and inflections were shifted from their canonical positions, as well as sentences which violated inflection alone (e.g., *They used to sing in these chairs on the porch* > *They used to sing**s*** *in these* ***chair*** *on the porch*). However, they were not sensitive to ungrammatical sentences that violated word order alone. In addition, removal of adjacent FW cues from the sentences

disrupted infants' preference for the grammatical sentences, and the replacement of the familiar CWs by nonce words has a similar effect. Thus, the authors concluded that it is early sensitivity to the relationship between FWs and CWs in phrasal constructions, rather than sensitivity to either independently, which guides the development of early grammatical knowledge (Soderstrom, White, Conwell, & Morgan, 2007).

Infants are not only aware of the relationships between FWs and CWs in general, but also more specifically between free and bound grammatical morphemes, and they may recognize this relation even when the components are discontinuous. From four months of age, infants have been found to consult not only the local relationship between a FW and an adjacent lexical item, but also non-adjacent dependencies between FWs within the general sentence contexts in which these appear. Brain responses from an ERP study revealed that 4-month-old German-learning infants quickly learned the non-adjacent relation between an auxiliary and a verb inflection in a novel language, Italian. The German-acquiring infants were presented with sets of Italian grammatical sentences, e.g., corresponding to *The sister is V-ing* or *The sister can V*, using a variety (32) of different verbs, and then tested on grammatical or ungrammatical sentences (the latter created by interchanging the auxiliary verb and the suffix, e.g., *can verb-ing*). The results showed that the infants extracted dependencies between non-adjacent elements in sentences, reflected in the form of a more positive wave for grammatically incorrect vs. correct dependency relations, indicating a grammatical effect (Friederici, Mueller, & Oberecker, 2011).

18-month-olds showed a significant listening time preference for passages in which the auxiliary *is* was followed by a main verb ending with the FA *-ing* (e.g., *everybody is baking bread*) hence forming a grammatical sentence, rather than for sentences which contained an ungrammatical combination of the modal auxiliary *can* and a main verb ending with *-ing* (e.g., *everybody can baking bread*; Santelmann & Jusczyk, 1998). Infants appeared to recognize that the functional morphemes *is* and *-ing* – although not directly adjacent in sentences – are structurally related to each other in English phrases and sentences. German-acquiring 19-month-olds computed discontinuous dependencies, such as between auxiliaries and past participles, in spite of the additional lexical, phonological and syntactic complexity which characterizes German

compared to English (Höhle, Schmitz, Santelmann, & Weissenborn, 2006). In another study, 17-month-old French-acquiring infants perceived the relation between grammatical dependencies even when the intervening forms were nonsense words (van Heugten & Shi, 2010). Gomez (2002) provided evidence from a nonsense language that 18-month-olds computed non-adjacent dependencies in three element strings.

An ERP study with 18-month-olds also provided evidence that French learning infants consider non-adjacent sentence context when representing FC (Brusini et al., 2017). In French, *la* is ambiguous between noun determiner or object clitic. Only sentential context will differentiate this ambiguity, e.g., *Hier la*…('yesterday the…') preceding a noun versus *je la*… ('I it …') preceding a verb. Infants were presented with short video clips and a native French speaker narrating a 30s story. Infants differentiated ungrammatical sentences where there is a misrepresentation of the *la* morpheme (**L'animal et* ***la*** *donne sont heureux* 'The animal and the give are happy') from grammatical sentences with the appropriate use of 'la' (*Alors moi je* ***la*** *donne au crocodile* 'Then I give it to the crocodile'); they showed a late positivity effect (which is robustly observed across ages for ungrammatical sentences) even when the FW (*la*) and the following word were phonetically identical. Hence, infants considered sentence context and anticipated form class based on preceding context, distinguishing between noun and verb contexts for the ambiguous FW *la*. This result pattern replicates with two-year olds (Bernal, Dehaene-Lambertz, Millotte, & Christophe, 2010).

Thus, both behavioral and neural evidence demonstrate that infants and toddlers consider sentential context, i.e., syntax, as well as stem and affix in morphology. They consult these in detecting and computing discontinuous dependencies, which are crucial to sentence structure and its meaning.

(v) Using FCs in word order

By eight months of age, infants appear to use FCs in a very basic aspect of grammatical organization, i.e., the organization of word order and basic grammatical directionality. In an artificial grammar experiment eight-month-old Japanese and Italian infants revealed opposite ordering preferences based on position of FC, consistent with the opposite ordering structures of their language (Gervain et al., 2008). In general, FCs acting as head

of constituents determine head direction or more generally branching direction of a language, often corresponding to what is sometimes called 'SVO' or 'SOV' languages. This variation has long been known to determine systematic variation in early acquisition of syntax across languages in older children (e.g., Gair et al., 1998; Lust & Wakayama, 1979; Lust & Chien, 1984; Lust & Mazuka, 1989; Lust, 1983; Lust & Mangione, 1983; Somashekar et al., 1997). Noting that FW are high frequency and occur at left or right edges of phrases depending on language typology, Gervain et al. (2008) presented infants, in a Head Turn Preference paradigm, with test strings of phonemes with FW-like items (distinct in the familiarization versus test phases) occurring either initially or finally in the string. Children acquiring Japanese and Italian showed opposite looking patterns in keeping with the directionality differences of their language. Japanese infants looked longer at the FCs final strings, whereas Italian infants did the reverse. These results imply that the position of FWs relative to CWs in a sentence may provide early cues to this abstract property of grammatical organization. These results are consistent with earlier study using a preferential listening technique (Shady, Gerken, & Jusczyk, 1995). 10.5-month-old infants discriminated normal English sentences from sentences in which determiners and nouns were reversed, e.g., *She knew her brother's tiny hungry meows* and *She knew brother's her tiny hungry meows*, thus demonstrating a general sensitivity to word order. These stimuli were recorded with synthetic speech to eliminate prosody that is likely to differentiate grammatical and ungrammatical sentences in natural speech, implicating reference to abstract order in the infants.

(vi). Using FC's in online processing

The wide access to FCs, which has been documented in early language acquisition research, has been shown to affect language processing by children's first birthday in spite of frequent omission of FWs in early speech. Early sentence processing appears to be advantaged by reference to FCs during early developmental stages surrounding first words. Thus, FCs not only contribute to grammatical construction but also to parsing language input. Kedar et al. (2017) found, by 12 months of age, some prototypical form of sensitivity to determiners in sentence processing and its use in computing noun reference. By 18 months, lexical access is speeded and more accurate when known CWs

(nouns and verbs) are preceded by a FW from an appropriate category (i.e. determiners and pronouns, respectively, Cauvet et al., 2014; Kedar et al., 2006, Kedar et al., 2017; Zangl & Fernald, 2007). Through an Intermodal Preferential Looking methodology measuring online processing efficiency, 18-month-olds' sentence processing was shown to be hindered by sentences using nonsense FWs (e.g., *Look at loo shoe*) as compared to sentences with grammatical determiners (e.g., *Look at the shoe*; Zangl & Fernald, 2003).

Recent research showed that 2.5- and 3-year-olds used agreement markers in preceding verbs to pre-activate features of an upcoming noun, shifting gaze to target in agreement informative questions such as *Where are the good cookies*? versus *Do you see the good cookies*?, thus demonstrating use of FWs in predictive processing (Lukyanenko & Fisher, 2016).

(vii) Consulting FCs to compute semantic reference

Crucially, infants and toddlers have been shown to employ FCs in the most foundational task of language knowledge, namely, the integration of syntax and semantics (form and meaning). Recent research has shown that at the earliest periods of acquisition, even before much word meaning has been acquired, FCs are integrated in grammatical knowledge by assisting in an essential function of language, i.e., mapping from the syntax of a sentence to reference. In experiments with 18- and 24-month-olds using an Intermodal Preferential Looking task, Kedar et al. (2006) found that infants consulted the head of the DET Phrase in sentences in realizing reference to a visual image, which corresponded with a target word (a noun). When hearing grammatical sentences in which the determiner *the* preceded a target noun, infants showed more correct first looks and faster fixations (latency to target) to the relevant image in comparison to their looking behavior in three ungrammatical conditions in which *the* was either dropped, replaced by a nonsense FW (*el*), or replaced by an alternate English FW (*and*). Recently, in a comparable experiment with 12-month-olds, with a new set of stimuli where all FWs were additionally controlled phonetically to be consonant-initial (*the*, *by*, *bo*; ruling out acoustic variables in a FW/CW distinction), Kedar et al. (2017) found results converging with those from 18- and 24-month-olds. The 12-month-olds also discriminated and favored the grammatical determiner in their looking behavior to the noun referents. Here

too, infants must be integrating general sentence context, since for example, *Can you see by…* or *Can you see and…* could in themselves initiate well-formed sentences, and both ['…*by N*'] and ['…*and N*'] are well-formed local dependencies. A similar pattern of results was reported for 21- to 28-month-olds, tested in a picture-identification task (Gerken & McIntosh, 1993), highlighting the robustness of these findings (task independence) and indicating continuity over development. Assessing mechanisms that underlie such early reference, Hochmann (2013) has provided evidence for the roles of both frequency and position of FWs when 17-month-olds compute object reference, tested through an artificial speech stream.

The grammatical categorization through FCs, which was evident in infancy, also continues through early childhood and has implications for development of comprehension in general. For example, 14-month-old English-learning children distinguished *a blicket* (count noun) vs. *blickish* (adjective) (Waxman & Booth, 2001; 2003). Development of abstract grammatical knowledge such as grammatical categorization of nouns (as in grammatical gender represented in FCs in French; where gender would be appropriate to specify reference), begins to be evident in 20-month-olds, and has been found to be robust at 30 months (Cyr & Shi, 2013). 24-month-old toddlers acquiring German have been shown to form grammatical gender categories as well as semantic categories and use their interaction in support of picture target recognition (Bobb & Mani, 2013).

Golinkoff, Hirsh-Pasek, & Schweisguth (2001) tested 18- to 21-month-old infants' sensitivity to the suffix *-ing* attached to a verb stem in determining comprehension. In an Intermodal Preferential Looking task, the infants were presented with three types of linguistic stimuli: a grammatical form (e.g., *dancing*), an ungrammatical form (e.g., *dancely*) and a nonsense form (e.g., *dancelu*). Three groups of infants were each assigned a single type of bound morpheme (*-ing, -ly, -lu*), with test trials using different verbs (e.g., *dance, drink*). Visually, two dynamic actions were presented simultaneously, of which only one action matched the verb stem. The grammatical bound morpheme *-ing* attached to the verb stem was the best predictor of infants looking longer at the matching screen.

By two years of age, toddlers have been shown to exploit the syntactic context of a novel word to infer whether it refers to an object or an action. 23-month-old children acquiring French watched videos where an object was performing an action and were taught a new CW (verb or noun), distinguished by a FW: *Regarde, elle dase!* ('Watch, it's dazzing!') vs. *Regarde la dase!* ('Watch the dazz!'). They interpreted the new word as a verb only when in verb contexts, thus suggesting that they were using syntactic contexts and related FCs to begin to determine word meaning, e.g., as object or action (Bernal et al., 2007).

French-learning 2-year-olds used the gender (Melançon & Shi, 2015; Van Heugten & Shi, 2009) and number features of determiners online (Robertson, Shi, & Melançon, 2012), to shift their gaze more quickly to a target picture if its name was preceded by FW cues that were informative of the referential context. Similarly, English-learning 2.5-year-olds used number morphology on nouns to identify the referents of novel nouns (*Look at the gooms*; Jolly & Plunkett, 2008). Two-year-olds were shown to use multiple cues to number in sentences such as *There are some blickets* (vs. *There is a blicket*_) to direct their attention to a many- as opposed to a single-object display (Kouider, Halberda, Wood, & Carey, 2006). Analyses of visual fixations showed that a preference for the target (one object in singular trials, multiple objects in plural trials), emerged before the onset of the number-marked novel noun itself, showing a predictive use of FWs - either the agreeing verb, the quantifier, or both (*are some* vs. *is a*).

The results reviewed here confirm early evidence suggesting that grammatical form determines word meaning in early language acquisition even before regular overt FC production. For example, 17-month-olds considered novel words (e.g., *dax*) as proper or common nouns based on the type of determiner that preceded them; they distinguished an object presented as *a dax* as a common noun, but *dax* as a proper noun (e.g., Katz, Baker & Macnamara, 1974; and see Gelman & Taylor, 1984 for an advanced design of this study). In general, the use of FWs through development suggests that FCs provide an integral component of the integration of syntax with semantics as well as pragmatic context during language acquisition and a powerful support for new word learning.

3. Accessing FCs in early production

Over the past few decades, studies have revisited the ostensible omissions of FWs in early child production using more rigorous methodology for collecting and analyzing spontaneous speech (e.g., larger samples, cross-linguistic samples) as well as experimental methods. The emerging pattern overall now seems to converge with the infant studies reviewed above. FCs are accessed in speech production even when not overt.

Indeed, it has long been known that toddlers respond better to commands in comprehension tasks when the FCs they omit in their own productive speech are in fact present in the command. For example, two seminal studies demonstrated that so-called 'telegraphic-speaking' children responded to utterances that contained FWs more successfully than to utterances where FWs were omitted (Shipley, Smith, & Gleitman, 1969; Petretic & Tweney, 1977). These seminal results suggested that children's early productions may underestimate their knowledge.

Subsequently, in an experimentally-designed elicited imitation task with sentence types as in (2), Gerken et al. (1990) found that, even though they were not generally producing FWs in their spontaneous speech, 26-month-olds differentiated well-formed from non-well-formed FWs. This documented that the children differentiated the FWs and encoded them.

(2)

Content	Function	
English	English	Pete pushes the dog
English	Nonsense	Pete pusho na dog
Nonsense	English	Pete bazes the dep
Nonsense	Nonsense	Pete bazo na dep

Children omitted the real FCs significantly more than the nonsense FCs even though they performed better (more accurately) in repeating the sentences with grammatical versus non-grammatical FCs. Thus, the (grammatical) FCs facilitated performance. Egido (1983) confirmed this result pattern with an older group, 3- to 5-year-olds, documenting continuity of the facilitating effect of FCs on performance.

More recent evidence has confirmed these early results. For example, in a comprehensive, in-depth investigation, combining both observational and experimental study of 28 French-acquiring toddlers (23 to 37 months), Dye (2009, 2011) probed FW production (focused on AUX) at multiple (i.e., syntactic, semantic, and phonological) levels. Spectral, phonetic and phonological analysis of contexts for compound verb forms (involving auxiliary + nonfinite forms) in the observational data revealed a wide range of early instantiations of auxiliaries. The results showed that contexts which in adult language require an auxiliary may display, for example, a pause or a breath in children's productions, suggesting that in some cases, children have planned for the apparently missing auxiliary even if no segmental content was realized (a result consistent with experimental evidence that children's omissions of unstressed syllables leave traces, i.e., pauses, Carter & Gerken, 2004). In other instances the auxiliary form, inaudible, could only be identified based on spectrographic analysis. Figure 1 illustrates spectrographic analysis revealing the presence of a fricative, [*f*], preceding what was heard as only a non-finite verb (i.e., with an ostensibly missing auxiliary). Inspection of the linguistic and pragmatic context of the child's utterance showed that in fact this utterance occurred in a sequence where the child uttered *faut lever [fo leve]* 'must lift' several times. The element preceding the non-finite verb was thus a half pronunciation of the auxiliary *faut [fo]* 'must'.

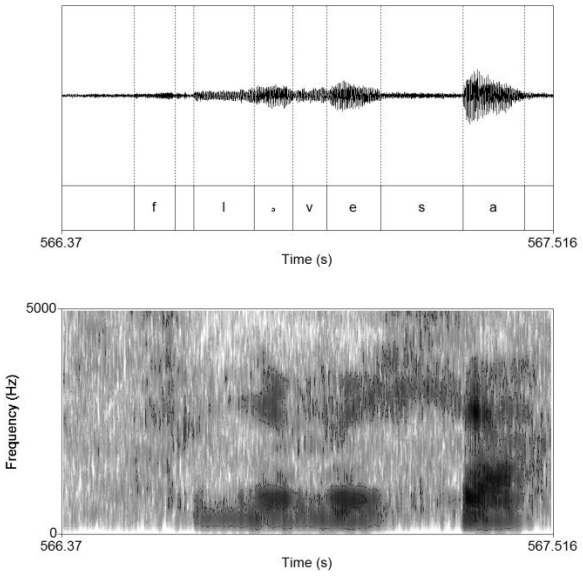

Figure 1: Spectrogram of a 2;2 year old child's utterance *f lever c¸a [f leve sa]* (*=faut lever c¸a [fo leve sa]*) 'must lift.INF this' (Dye, 2011)

In yet other instances, children's AUX forms involved a reduced vowel (e.g., schwa) or some other (audible) segment or segment combination standing for the auxiliary (though not necessarily displaying phonetic features from the target auxiliary).

The latter finding converges with a growing body of literature on "proto-syntactic devices". A number of studies have described in detail the occurrence of such elements in the early periods of production. These elements have been variously referred to as 'proto-functors' (e,g., Bottari, Cipriani & Chilosi, 1993/1994), 'fillers' (e.g., Pepinsky, Demuth, & Roark, 2001), 'pre-syntactic devices' and 'transitional phenomena' (Dore, Franklin Miller & Ramer, 1976), 'place holders' (e.g., Bloom, 1970), or 'prefixed additional elements' (Veneziano & Sinclair, 2000). They consist of audible segments that involve non-target phonetic features. For example, they tend to consist of vocalic segments (mainly [*schwa, e, a*]: "rather than being associated with a specific phonetic feature they are realized within a phonetic space, the low central area" (Bottari et al., 1993/1994, p. 331). In other cases, they may involve a combination of a vowel and a consonant (but still diverging from the target form). They tend to be found in those slots where functional items are expected in adult language (i.e., in English, often preceding lexical items). They begin to appear in the early periods of production when children's utterances involve no more than one or two words and disappear over time with the emergence in production of functional items. This type of form has been documented in the speech of monolingual, and bilingual children as well as children with cochlear implants, across English (e.g., Peters & Menn, 1993), Italian (e.g., Bottari et al., 1993/1994), French (e.g., Kilani-Schoch & Dressler, 2001; Tremblay, 2005), Spanish, (e.g., Lleo, 2001), Catalan (e.g., Bartra 1997), German (e.g. , Lleo 2001, Dressler & Karpf, 1995), or Sesotho (Connelly, 1984). Although initial studies were cautious about the status of these elements (which have been argued to serve a phonological, morphological or syntactic role) it has now become clearer that these indeed represent early 'incarnations' of FWs (e.g., Belikova et al., 2009), indicating that FCs are accessed in early production.

In sum, a wide variety of research now confirms continuity between early infant studies which confirm discrimination and access of FCs and their role in early speech production.

4. Advancing grammar

Finally, if infants and young children very early are not only accessing FC, but using them to build grammatical representations in their language, then we would expect to find continuity further with older children and with more complex sentence formation. Research on the wide array of FCs in more advanced syntax and semantics in language acquisition, including COMP, is more accessible with older children where various forms of complex sentences become evident in speech and experimental methods can target FCs and their grammatical consequences. We are unable here to include a comprehensive review of this extensive research. For example, researchers have studied the interaction of FCs with operations such as pro drop, verb movement, verb finiteness, and WH movement, such as in relative clauses and question formation which involve FCs including COMP (e.g., Lust, 1994; Lust, Foley & Dye, 2015; Lee et al., 1990; Whitman, Lee & Lust, 1991; Hyams, 2014; deVilliers, Roeper & Vainikka, 1990).

For example, one experimental study has investigated the role of COMP in grammatical organization, using an elicited imitation task, to compare Spanish and English 'pro drop' (or subject omission) in subordinate clauses, introduced by COMP. Here English pro drop is not allowed, e.g., (3), in contrast to Spanish where it is, e.g., (4) (Nunez del Prado, Foley, Proman & Lust, 1997). With matched designs, and matched Spanish and English age groups (2.2 to 4.5 years), results showed that in contrast to performance on coordinate structures where there were no cross-linguistic differences in children's pro drop production, children acquiring English produced a significantly lower amount of null subjects (under 2%) as in (3) in the subordinate clause domain than the Spanish as in (4) (over 20%); thus documenting a sensitivity to the CP subordination domain in their specific language grammar at early ages in both groups.

(3) "Bunny says that Bunny dances" - > *Bunny says that 0 dances

(4) "Rene dice que Rene corre" - > Rene dice que 0 corre

Given the rich research data now available with infants and toddlers, and the extensive research available on syntax acquisition in older children, such as the study above, it will now be possible to begin to merge these early infant and later language acquisition research programs in order to attain a full developmental theory.

Recent research provides evidence that early access to FCs correlates with grammatical development in general. Le Normand, Moreno-Torres, Parisse, & Dellatolas' (2013) investigation of spontaneous speech from a large sample of French-speaking children aged 2-4 years correlated the diversity of word types in various form-classes with the children's MLU in words and found that the number of grammatical word types was a more powerful predictor of grammatical complexity than the number of lexical word types.

A study of German-speaking children with cochlear implants showed that the early use of determiners was highly predictive of the children's subsequent grammatical progress (Szagun & Schramm, 2016). Type and token frequency of determiners in the children's earliest multiword utterances were more strongly related to subsequent MLU than was early vocabulary size. According to the authors, this may point to a decisive role of early determiners in grammar building. Diversity of determiners furthers grammar building by generalizing the same grammatical relation over different items of the noun class. Frequent determiner use practices the grammatical relations of case and gender. The strong impact of determiners on grammatical progress suggests that some generalized knowledge of how sentence constituents relate to one another is present in early multiword utterances and drives the construction of grammar. A study based on parent-report data in CDI format from a sample of 1151 German-speaking children between 1;6 and 2;6 and longitudinal spontaneous speech data from 22 children between 1;8 and 2;5 reported regression analyses which showed that grammatical words have a stronger influence on concurrent syntactic complexity than lexical words (Szagun & Schramm, 2018).

Finally, Ninio (2017) has provided evidence for generalization across structures in early child speech, which implicate FCs and their role as heads of phrases. In a study of natural speech samples of early two-word sentences in 407 English- acquiring children (mean age 2.0), higher correlations were found in these early sentences between

children's use of determiner-noun combinations and verb-object (or indirect object; as well as subject-verb) constructions, both of which arguably reflect head-complement structures, in contrast to expressions with attributive adjective-noun combinations (e.g., comparing '*want juice*' vs. '*big truck*'). Since attributive adjective-noun combinations do not directly reflect head-complement structures, and do in fact reflect lexical content word based constructions, it is argued that these structures represent an outlier in syntactic relations reflected in determiner-noun constructions; thus, the head-complement structure does not generalize to these. The determiners, not the verbs, were most strongly predictive, perhaps suggesting that the abstraction of the FC may aid effectiveness in grammatical acquisition over and above the semantics of the lexical item of the verb. If such differential correlations do prove to be related to underlying syntactic contexts of the various constructions studied, and the correlations do in fact reflect a syntactic principle which generalizes, e.g., one underlying head-complement formation, it will be important to explore the representation which underlies such grammatical generalization and its role in language acquisition.

5. Conclusion

This brief review has culled evidence for an early and wide sensitivity to FCs in language acquisition, one that initiates at birth, long before word or sentence meaning is available to the child; and which is continuous through early speech production and later syntactic acquisition. This sensitivity to FCs is reflected in discrimination and access of FCs, but, more importantly, in their wide role in grammatical acquisition (both syntax and semantics), as well as in language processing. Our review suggests that infants continually can and do, very early, compute sentence structure in connection with FCs, and they do so computing FCs as a category. Infants consult FCs in early grammatical category formation (distinguishing nouns from verbs) and in computing essential syntactic and semantic operations such as involved in non-adjacent agreement relations. They use FCs very early to assist in determining the semantics of a sentence, including reference; and they use FCs to build word meaning. These results, from a wide array of methodologies, have revealed new foundations for language acquisition. Rather than assuming that the child begins with and builds on 'first words', we now see that language

development begins long before production of first words, and that FCs are essential to this development from the beginning. These results have begun to be documented across languages with various typologies, suggesting a possible universal foundation for language acquisition.

The roles played by FCs at early points of language acquisition converge with the generalization that in acquisition "form is easy, semantics hard" (Naigles, 2002, p. 157). In spite of the dearth of meaning involved in FCs, in spite of their formal "functional' grammatical roles, in spite of the absence of semantic and pragmatic knowledge at earliest periods of language development, FCs operate in earliest language acquisition continuously (e.g., Valian & Coulson, 1988). This evidence suggests that FCs are essential to syntactic bootstrapping in language development (Gleitman, 1990). FCs appear to aid the development of the CWs such as nouns and verbs.

The evidence has documented a continuous role for these FCs in grammatical computation, thus supporting a 'continuity' view in language acquisition. At the same time, however, it is clear that much remains to develop over time with regard to FCs. The remarkable continuous access to FCs does not signify that FC development is complete. Behaviorally, for example, young infants' discrimination of FWs becomes more precisely specified phonetically over time (See Shi, 2013, for a review). For example, in English the mispronounced *ke* (for *the*) is acceptable to infants before 11 months (Shi et al., 2006). Phonetic and lexical learning for specific FWs is clearly necessary.

More generally, a full developmental theory must consider the necessary development of an integration of complex syntax, semantics and pragmatics, which characterize FCs. For example, DET in English is dependent on complex syntactic and pragmatic factors, e.g., an existential presupposition in the case of 'the', and various ambiguities of reference for both 'the' and 'a'. In a study of comprehension with 95 3- to 7-year-old children and an adult control group, Foley et al. (2000) found that independent of continuity in syntactic acquisition, developmental changes occurred in indefinite and definite interpretation through 7 years old and adults.

A full developmental theory must explain cross-linguistic differences in FCs that are demonstrated early in development. For example, sensitivity to FWs may emerge

earlier in French (Shi, Marquis & Gauthier, 2006). There are general cross-linguistic differences in early segmentation of speech (Nazzi et al., 2005). Variation in timing of overt FCs in early speech production is well known (e.g., Aksu Koc & Ketrez, 2003; Choi & Gopnik, 1995; Demuth, 1990; Hyams ,2014; and see Gervain et al., 2008, p. 59, for a discussion of FW variation across languages). Some have hypothesized regarding the nature of this development. Clahsen (1991), for example, suggested that young children initially have a single, underspecified functional projection; according to others FCs may exist in some abstract form but with underspecified features. This proposal has been advanced by researchers studying higher order syntax acquisition (e.g., syntactic operations of verb movement, Deprez, 1994; Demuth, 1994; Hyams, 1996). Children may adopt a general FC until language -specific variants are acquired (e.g., the Chinese child's use of a general classisfier, *ge*, in early language acquisition, Chien, Lust & Chiang 2003). Jakubowicz (2003) proposed a hypothesis of 'Computational Complexity' as underlying FC development and cross-linguistic differences in acquisition. The question remains: What is the nature of the initial FC representations? What is the nature of the abstract primitive FCs?

Both prosody and FC representation must develop together as language-specific grammar develops. Many studies confirm the early role of prosody in children's syntactic analysis, e.g., Carvalho et al., 2016; Shady et al., 1995; Christophe, Millotte, Bernal & Lidz, 2008; Massicotte-Laforge & Shi, 2015; Gerken, 1994 and Demuth, 2018, for initial construction of a developmental theory in which a convergence of FCs with phrasal prosody may underlie syntactic acquisition (e.g., a Prosodic Licensing Hypothesis).

Finally, we may expect that developing language processing mechanisms may interact with the developing syntax and semantics of FCs. Studies based both on spontaneous and experimental data have provided evidence that children's impoverished production of FWs in early production is based on limitations in speech processing factors, as well as phonological factors such as prosody (e.g., Demuth, 1992; Dye, 2005, 2011; Gerken, 1994; Kirk & Seidl, 2004; Valian, Solt, & Stewart, 2009; Sorace et al., 2009; and see Demuth, 2018, for a phonological explanation). Earlier research with older children had suggested that children's processing of closed-class items became more 'automatic' with time. For example, in a word monitoring sentence processing task, 5-11

year-olds demonstrated developmental changes in reaction times and changes in consideration of semantic context in FC monitoring (Friederici, 1983). Further research will be necessary to pursue the integrative mechanisms relating syntactic and semantic components of FC access and knowledge in the development of language processing.

The fundamental issues raised by our review thus are: (a) What is the nature of initial programming within the child which determines both the early and continuous access to FCs in language acquisition, and the grammatical organization which the FCs so early and continuously underlie; and (b) What is the nature of development by which this programming leads to final acquisition of a specific-language grammar?

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