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Early Bootstrapping of Syntactic Acquisition*

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ABSTRACT: Infants acquiring language have to learn about the lexicon, the phonology, and the syntax of their native language, among others. For each of these domains, being able to rely on knowledge from the other domains would simplify the learner's task. For instance, having access to words and their meaning should help infants to learn about syntax, but learning about the meaning of words would be greatly facilitated if infants had access to some aspects of syntactic structure (GLEITMAN, 1990).

Key-words: language acquisition, bootstrapping, syntax

Introduction

This chapter focuses on how phrasal prosody and function words may interact during early acquisition. Experimental results show that infants have access to intermediate prosodic phrases (phonological phrases) during the first year of life, and use these to constrain lexical

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segmentation. In addition, by two years of age they can exploit function words to infer the syntactic category of unknown content words (nouns vs verbs) and guess their plausible meaning (object vs action). We speculate on how infants may build a partial syntactic structure, the 'syntactic skeleton', by relying on both phonological phrase boundaries and function words, and present adult results strengthening the plausibility of this hypothesis.

Children learning their mother tongue are faced with a difficult task: they have to acquire the phonology of the language, construct their vocabulary and discover the syntactic rules governing the organisation of words within sentences. For each of these domains, being able to rely on knowledge from the other domains would simplify the learner's task. For instance, since syntax spells out the relationship between the words in sentences, it makes sense to assume that infants need to have access to words and their meanings in order to learn about syntax. Conversely, learning about the meaning of words would be greatly facilitated if infants had access to some aspects of syntactic structure (GILLETTE, GLEITMAN, GLEITMAN & LEDERER, 1999; GLEITMAN, 1990). These potential circularities can partially be solved if infants can learn some aspects of the structure of their language through a low-level, purely phonological analysis of the speech input they are exposed to (the phonological bootstrapping hypothesis, see Morgan and Demuth, 1996).

In this chapter we will concentrate on the beginnings of language acquisition, more specifically that of syntax. In particular, we examine the role of two sources of information to which very young infants may plausibly have access: phrasal prosody and function words.

Prosody can be defined as the rhythm and melody of an utterance. The prosodic bootstrapping hypothesis postulates that children may use the prosodic characteristics of sentences to learn certain aspects of their mother tongue, particularly its syntax (CHRISTOPHE, GUASTI, NESPOR & VAN OOYEN, 2003; GLEITMAN & WANNER, 1982; MORGAN, 1986; NESPOR, GUASTI & CHRISTOPHE, 1996). We focus on intermediate prosodic units, phonological phrases: these units depend on the syntactic structure of sentences and characteristically contain one or two content words along with the function words associated with them (NESPOR & VOGEL, 1986). Phonological phrases are characteristically marked by final lengthening and strengthening of the initial phoneme. They tend to have a single intonation contour per phonological phrase with a possible discontinuity of the F0 contour at the juncture of two units (cf. SHATTUCK-HUFNAGEL & TURK, 1996, for a detailed review).

The second source of information, function words and morphemes, are grammatical elements such as articles, pronouns, auxiliaries, and conjugation endings. Children may discover them in the speech signal relatively easily because they are extremely frequent syllables generally appearing at the boundaries of prosodic units. These function words also have acoustic, phonological and statistical characteristics that children could use to extract them from sentences and differentiate them from content words (SHI, MORGAN & ALLOPENNA, 1998; GERVAIN, NESPOR, MAZUKA, HORIE & MEHLER, 2008; HOCHMANN, ENDRESS & MEHLER, 2010).

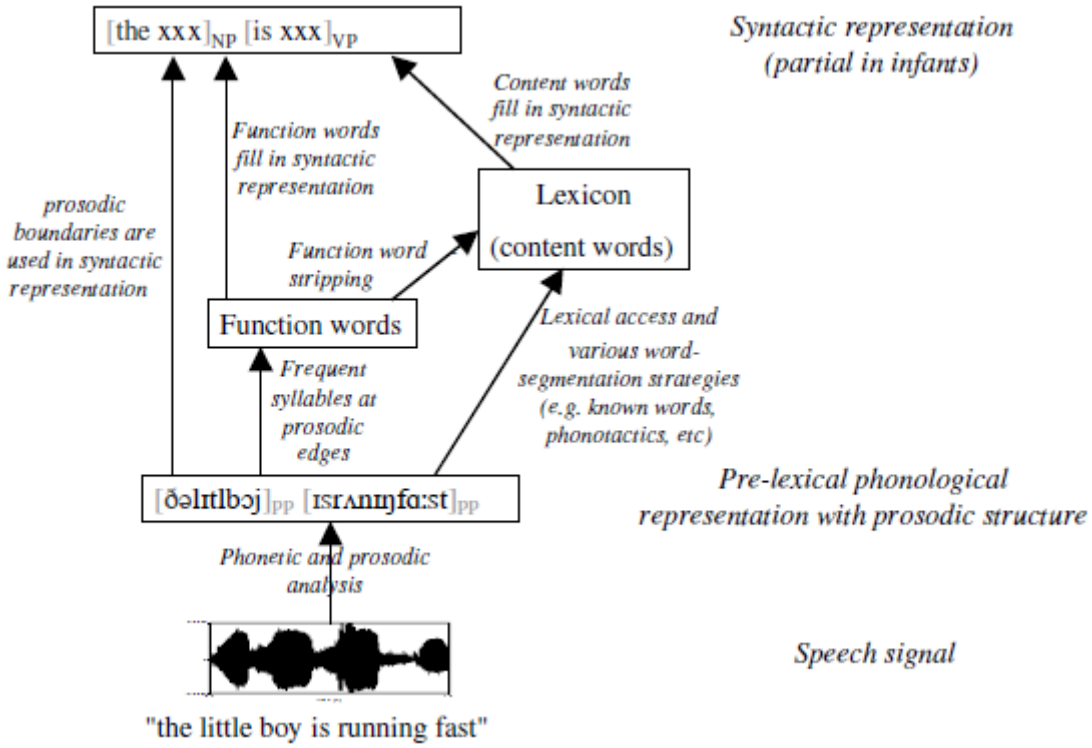

Figure 1: A model of language acquisition by infants and speech perception by adult speakers (figure adapted from Christophe et al. 2008)

These two sources of information, phrasal prosody and function words, may be integrated in a model of language acquisition (CHRISTOPHE, MILLOTTE, BERNAL & LIDZ, 2008, see figure 1). Starting from the bottom, this model claims that children are able to construct, on the basis of the acoustic signal, a pre-lexical representation that is segmented into prosodic units. Prosodic boundaries are perceived by young infants (see e.g. GERKEN, JUSCZYK & MANDEL, 1994; SODERSTROM, SEIDL, KEMLER NELSON & JUSCZYK, 2003; NAZZI, NELSON, JUSCZYK & JUSCZYK, 2000), and have been shown to be interpreted by infants as word boundaries (CHRISTOPHE, GOUT, PEPERKAMP & MORGAN, 2003; GOUT, CHRISTOPHE & MORGAN, 2004; MILLOTTE, MARGULES, DUTAT, BERNAL & CHRISTOPHE, in press). In addition, they may be directly used to constrain the syntactic analysis of sentences (we will discuss this in the first part of this chapter). In this pre-lexical representation, the most frequent syllables at the boundaries of prosodic units may be extracted from the signal and integrated into a lexicon of functional elements (CHRISTOPHE, GUASTI, NESPOR, DUPOUX & VAN OOYEN 1997; SHI & GAUTHIER, 2005; SHI, CUTLER, WERKER & CRUICKSHANK, 2006). This special lexicon may itself inform the syntactic processing of sentences, if infants are able to figure out co-occurrence relationships between functional elements (SODERSTROM, WHITE, CONWELL & MORGAN, 2007; SANTELMANN & JUSCZYK, 1998), and/or between functional elements and content word categories (an aspect we will examine in the second part of the chapter). Our working hypothesis is that children may construct a first-pass

syntactic structure of the sentences they hear by using prosodic cues and function words simultaneously: prosodic boundaries would be used to identify the boundaries of syntactic constituents, while function words would be used to label these syntactic units (noun phrase vs verb phrase, for instance). For instance, upon hearing the sentence "the little boy is running fast", the child may create an initial syntactic representation of the kind "[the XXX]$_{NP}$ [is Xing X]$_{VP}$" in which syntactic boundaries would be supplied by prosody while syntactic labels (noun phrase, verb phrase) would be supplied by function words and morphemes (perhaps especially those placed at the edges of prosodic units). This initial syntactic representation, or 'syntactic skeleton', could be constructed even without knowing the content words making up the sentence (in our example these words are represented simply as syllables in the form of Xs). This hypothesis will be developed and tested in the third part of this chapter.

1. Phrasal prosody constrains syntactic analysis

The first source of information crucial to the model is phrasal prosody. Since phonological phrase boundaries are aligned with the boundaries of syntactic constituents. It thus makes sense to assume that they may be used to constrain the syntactic analysis of sentences, not only by children, but also by adults. To test this hypothesis (corresponding to the direct arrow between the pre-lexical phonological representation and the syntactic representation, on the model in Fig. 1), we used homophones that may belong to two different syntactic categories to create temporarily ambiguous French sentences, such as:

Adjective sentence: "[le petit chien **mort**][sera enterré][demain]…"
*The **dead** little dog will be buried tomorrow*
Verb sentence: "[le petit chien][**mord** la laisse][qui le retient]…"
*The little dog **bites** the leash that ties him*

In these sentences, the first four words are pronounced in the same way, and the only way to figure out whether the fourth word is an adjective (*dead*), or a verb (*bites*) is to process the phonological phrase boundary, that is placed just before the ambiguous word when it is a verb (in the second sentence), and just after when it is an adjective (in the first sentence). These sentences were recorded by naïve speakers who were unaware of the ambiguities in the sentences. They were then cut at the end of the ambiguous word and presented to French adults in a sentence-completion task (subjects heard the beginnings of the sentences and had to complete these in writing). Results are shown in figure 2:

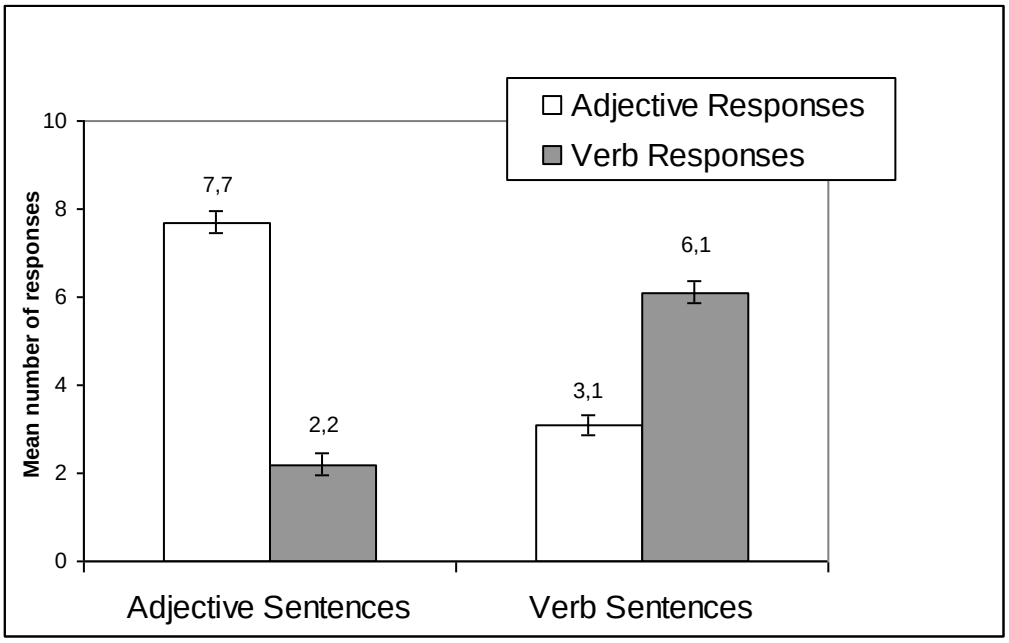

Figure 2: results of a sentence completion experiment in which participants listened to the beginnings of ambiguous sentences cut just after the ambiguous word. Subjects gave more adjective interpretations when listening to the beginning of adjective sentences and more verb ones when listening to verb sentences (figure adapted from Millotte et al., 2007)

We observed that participants were able to distinguish the beginnings of these sentences that differed only in their prosodic and syntactic structures. The sentence beginnings with adjective prosody were completed significantly more often with adjectives than with verbs, and vice-versa (MILLOTTE, WALES & CHRISTOPHE, 2007). The results were confirmed with an on-line word-detection task (MILLOTTE, RENÉ, WALES & CHRISTOPHE, 2008). These experiments thus show that the boundaries of phonological phrases are spontaneously produced, interpreted on-line as syntactic boundaries, and used to guide the syntactic analysis of sentences. They lend support to the hypothesis that phrasal prosody can constrain syntactic analysis on-line, as shown by the direct arrow going from the pre-lexical phonological representation with prosodic boundaries to the syntactic representation, in the model of Fig. 1

2. Function words signal the syntactic category of the following content words.

Once prosodic boundaries are identified interpreted as syntactic boundaries, children have to label the resulting units. To do so, they may use function words. For instance, a unit starting with an article is a noun phrase (or, part of a noun phrase). This supposes that the children have already identified a list of function words in their own language, a hypothesis supported by the results of several studies (HALLÉ, DURAND & DE BOYSSON-BARDIES, 2008; SHAFER, SHUCARD, SHUCARD & GERKEN, 1998; SHI & GAUTHIER, 2005; SHI ET AL., 2006). In addition, they must also have learned the links between categories of function words and categories of content words (between articles and nouns, for example, or between pronouns and verbs). Several studies have already shown that infants are able to

associate articles with nouns from the age of 14 months on (HÖHLE, WEISSENBORN, KIEFER, SCHULZ, & SCHMITZ, 2004; KEDAR, CASASOLA, & LUST, 2006; SHI & MELANÇON, 2010; ZANGL & FERNALD, 2007). For instance, infants orient faster towards a known object if the noun representing that object is appropriately preceded by an article (e.g. 'Where's the *book*?') than if it is incorrectly preceded by an auxiliary or a non-word (e.g. 'Where's po *book*?') (KEDAR et al. 2006, ZANGL & FERNALD, 2007). However, these studies did not show any ability to associate pronouns with verbs (see HÖHLE et al. 2004, SHI & MELANÇON, in press), and researchers have suggested that infants may find it harder to link pronouns with verbs, for two main reasons: firstly, the co-occurrence of pronouns and verbs may be less frequent than that of articles and nouns; and secondly, verbs typically represent actions, which are conceptually more complex than objects.

To test whether infants may also be able to link pronouns with verbs, we trained 18-month-old French infants to turn their head for a known word, either a noun (e.g. 'une balle' *a ball*), or a verb (e.g. 'il mange' *he eats*). In a second session, infants were tested on short sentences belonging to three experimental conditions: in *grammatical* sentences, the target word appeared in a syntactically appropriate context (e.g. 'la **balle** est rouge et verte' *the **ball** is red and green* for the noun target, or 'je **mange** une petite pomme' *I **eat** a small apple*, for the verb target); in *ungrammatical* sentences, we exchanged noun and verb targets, so that they now occupied an incorrect position, corresponding to a word from the other syntactic category (e.g. 'je **balle** une petite pomme' *I **ball** a small apple* vs 'la **mange** est rouge et verte' *the **eat** is red and green*'); last, in distractor sentences, the target word did not appear at all (e.g. 'la **fraise** est très bonne' *the **strawberry** is really good* vs 'Tu **donnes** des cadeaux à ton frère' *you **give** gifts to your brother*) .

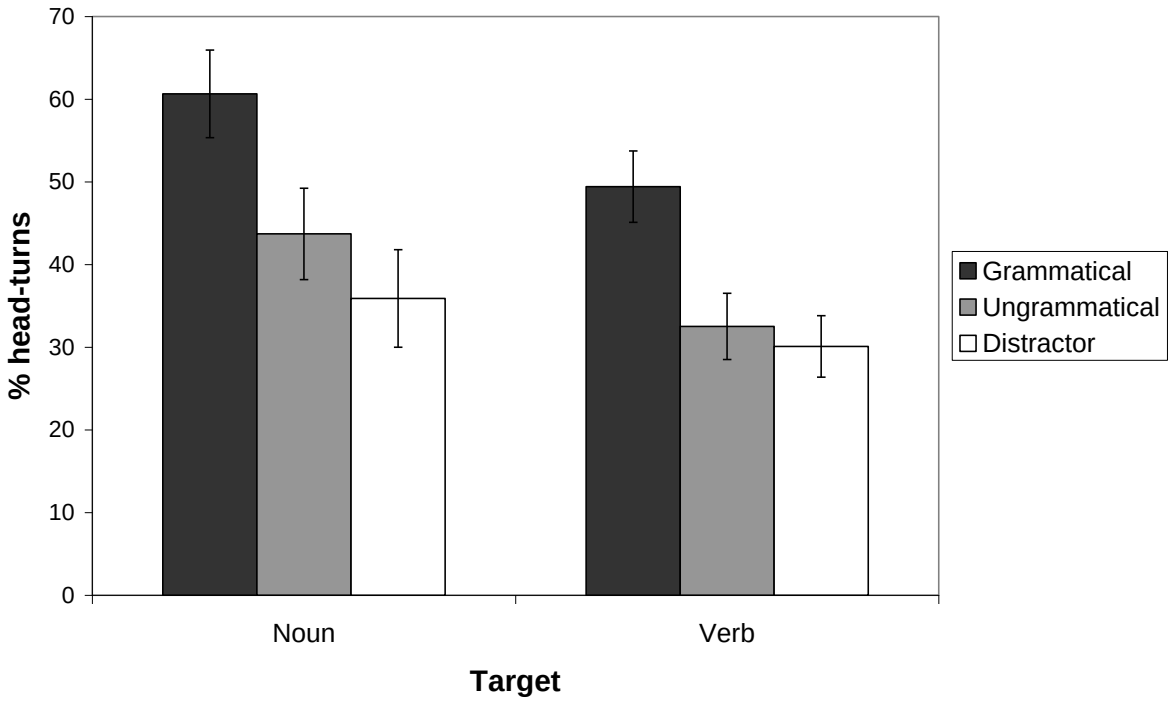

Figure 3: Results of a word-detection experiment with 18-month-old French infants trained to turn their head for either a noun (left-hand bars) or a verb (right-hand bars). In both cases, infants responded significantly more

often when the target appeared in a syntactically appropriate context (grammatical sentences), than when it appeared in a syntactically inappropriate context (ungrammatical sentences) or did not appear at all (distractor sentences; Figure adapted from Cauvet, Alves Limissuri, Millotte, Margules & Christophe, 2010).

The results showed that 18-month-olds responded significantly more often when the target appeared in a syntactically appropriate context, than when it appeared in an inappropriate position. In fact, infants did not respond significantly more often to sentences that contained the target in an inappropriate position, than to sentences that did not contain the target at all. They behaved as if they considered this target as an entirely new word, e.g. the verb 'baller' (*to ball*), or the noun 'la mange' (*the eat*), having nothing to do with the target word they were trying to identify. In addition, there was no asymmetry between nouns and verbs. This result thus suggests that 18-month-old French infants already know (some of) the contexts in which nouns and verbs occur in French. They expect known nouns and verbs to occur in contexts appropriate to their syntactic category, and treat items that occur in wrong contexts as different words. This results lends support to the hypothesis that infants may exploit function words to label prosodic units.

In a follow-up experiment with evoked potentials, we showed that at the age of 2 years, French toddlers exhibited differential brain responses to nouns and verbs that appeared either in appropriate or inappropriate contexts (BERNAL, DEHAENE-LAMBERTZ, MILLOTTE & CHRISTOPHE, 2010). Interestingly, in this experiment, we controlled transition probabilities between pairs of words by relying on the ambiguity between definite articles and clitic objects that exists in French (as in other romance languages, and several other languages). Thus, the verb 'mange'/*eat* appears in a correct context in 'je la mange'/ *I eat it*, but in an incorrect context in 'je prends la mange'/ *I take the eat*. Correspondingly, the noun 'fraise'/*strawberry* appears in a correct context in 'je prends la fraise'/ *I take the strawberry*, but in an incorrect context in 'je la fraise'/ *I strawberry it*. Even though this ambiguous function word 'la' (meaning *the* or *it* depending on its syntactic context) should make things harder for children, 2-year-olds clearly distinguished between correct and incorrect contexts. This suggests that by the age of 2 years, their knowledge of these function words of French is already fairly refined. In addition, these results were replicated in an experiment in which the nouns and verbs had just been learnt by toddlers, and had never been heard before in the test contexts (BRUSINI, DEHAENE-LAMBERTZ & CHRISTOPHE, 2009).

In an attempt to figure out what kind of computation may allow young infants to discover in what contexts words are supposed to occur, we built a model that computes transition probabilities between triplets of adjacent words. In order to simulate an infant with little knowledge to start with, and to take advantage of the fact that functional elements are so much more frequent than content words, this model started out with only two abstract categories, nouns and verbs. All other items were not categorized a priori, but represented as themselves. For instance, the word 'un'/*a* would be alone in its category, UN. The model thus had no a priori knowledge that there are classes of function words. However, since each of these functional elements is extremely frequent, they may well appear often enough in trigrams to remain informative. In a first step, the model was trained on an (irrealistic) training corpus where all nouns and verbs were correctly categorized: in this condition, the model achieved a performance of about 90% accuracy on a test corpus, for forced-choice noun/verb categorization, suggesting that trigrams do contain significant word category information, even when functional elements are not categorized. Interestingly, when the training corpus was made more psychologically plausible by assuming that the infant/model

only knew the category of the most frequent nouns and verbs of the training corpus (corresponding to the 5 most frequent nouns, and just one very frequent verb), the performance of the model went down but remained acceptable, around 75%. These results suggest that infants may be able to initially group words together on the basis of their immediate contexts. This first categorization would serve as a basis for further syntactic acquisition. Similarly, Toben Mintz proposed that young infants may focus on 'frames', pairs of non-adjacent words that frequently co-occur (MINTZ, 2003, CHEMLA, MINTZ, BERNAL & CHRISTOPHE, 2009). For instance, the frame 'you X it' selects exclusively verbs. It is thus possible that infants may start out categorizing nouns and verbs by paying attention to their immediate contexts.

Once infants know in what syntactic contexts nouns and verbs are supposed to occur, they can exploit this knowledge to assign a syntactic category to new words that have not been heard before. They can then use the syntactic category to infer something about the meaning of the word. Thus, nouns typically refer to objects, whereas verbs typically refer to actions. To test this, we used a word-learning task with 23-month-old children: they watched videos in which an object performed a simple action, and were taught either a new verb (e.g. 'Regarde, elle dase!' *Look! It's dasing!*), or a new noun (e.g. 'Regarde la dase!' *Look at the dase!*). The results showed that toddlers interpreted the new word as referring to the action only when it was presented in verb contexts (BERNAL, LIDZ, MILLOTTE & CHRISTOPHE, 2007; see also WAXMAN, LIDZ, BRAUN & LAVIN, 2009; HALL, WAXMAN, BRÉDART & NICOLAY, 2003). These results thus show that French 2-year-olds are capable of using the syntactic contexts in which unknown words occur to infer their syntactic category as well as their possible meanings (object vs. action). Overall, this series of results is consistent with the idea that infants as young as 18 months of age may be able to use functional elements in order to identify the syntactic category of neighbouring content words.

3. Building a 'syntactic skeleton' with phrasal prosody and function words

Our working hypothesis is that children might use function words and prosodic cues simultaneously in order to create a first-pass syntactic analysis of the sentences they hear, or 'syntactic skeleton'. To test the plausibility of this hypothesis, we presented French adults with 'jabberwocky' sentences in which only phrasal prosody and function words were preserved: all content words were replaced by non-words. With these stimuli, adults are thus placed in the situation of young children who would already know the phrasal prosody and function words and morphemes of their language, but not yet all the content words. Participants had to perform an abstract word detection task in which target words were specified with their syntactic category. There were two experimental conditions: in the 'Adjacent function word' condition, the target words were immediately preceded by an informative function word (nouns were preceded by articles, verbs by pronouns); in the 'Function word and prosody' condition, target words were preceded by another content word and a more complex analysis relying on *both* prosodic information *and* function words was necessary to perform the task. Examples of the experimental sentences are given below: ('pirdale' is the target word, and a possible French translation of the jabberwocky sentences is given below each test sentence; square brackets mark phonological phrases).

"Adjacent function word" condition
Verb sentence:
[Elle **pirdale**] [tru les sbimes] [de grabifouner]
[Elle **promet**] [toutes les semaines] [de téléphoner]
*She **promises** every week to phone*
Noun sentence:
[Un **pirdale**] [ga tachin proquire]
[Un **cadeau**] [fait toujours plaisir]
*A **gift** always gives pleasure*

"Function word and prosody" condition
Verb sentence:
[Un gouminet] [**pirdale** tigou] [d'aigo soujer]
[Un étudiant] [**promet** toujours] [d'être sérieux]
Noun sentence:
[Un gouminet **pirdale**] [agoche mon atrulon]
[Un incroyable cadeau] [attire mon attention]

French adults had to detect a word specified with its syntactic category; for instance, they had to detect the verb 'pirdaler' *to pirdale*, or the noun 'le pirdale' *the pirdale*. If the target was a verb, participants had to respond if the next sentence contained that verb, but refrain from responding if the next sentence contained a noun homophonous to that verb (and vice-versa for the detection of the target noun).

The results, presented in Figure 4, show that participants were perfectly able to use the presence of a function word to infer the syntactic category of the non-word following it ('adjacent function word' condition): in 90% of cases, a non-word preceded by an article was correctly interpreted as a noun, whereas it was interpreted as a verb when preceded by a pronoun. Participants were also able to jointly use function words and prosodic cues ("function word + prosody" condition): when the phonological phrase boundary was placed before the target non-word (verb sentence), participants gave 90% verb answers, whereas they answered at random for noun sentences, in which the target word was not preceded by a phonological boundary.

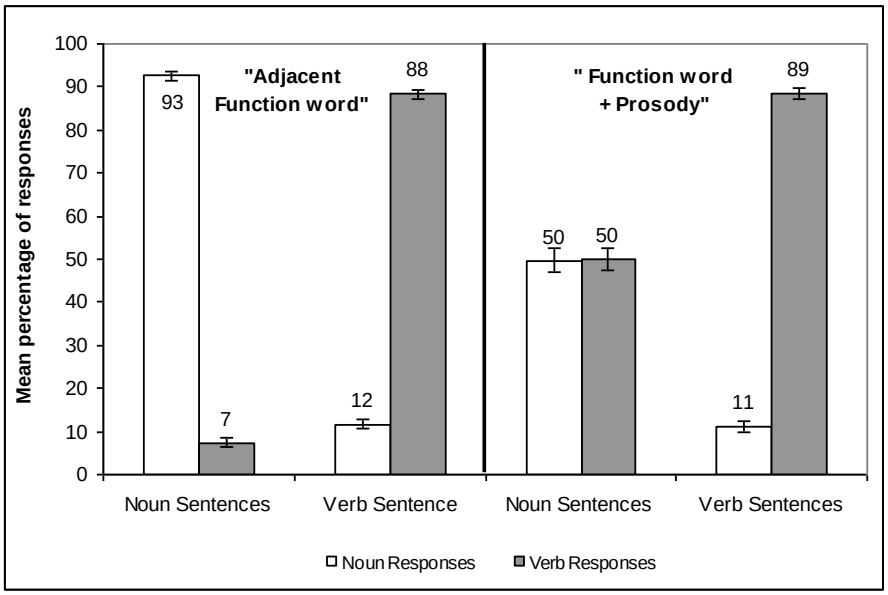

Figure 4: Results of an abstract word-detection task with jabberwocky sentences: subjects correctly identified the syntactic category of an unknown content word immediately preceded by a function word (left-hand bars). When the target word was preceded by another content non-word, subjects performed better than chance overall (figure adapted from Millotte, Wales, Dupoux & Christophe, 2006).

In this experiment function words and phonological phrase boundaries allowed listeners to construct a skeleton of the syntactic structure of sentences, even when they didn't know the meaning of the content words. To correctly interpret sentences such as "[Un gouminet] [**pirdale…]"**, participants had to use phonological phrase boundaries to establish syntactic constituents boundaries. They then used the function word "un" *a* to infer that the first constituent was a noun phrase: "[Un gouminet]$_{NP}$ [**pirdale…]"**. This noun phrase in turn is likely to be followed by a verb phrase, "[Un gouminet]$_{NP}$ [**pirdale$_{V}$…]**$_{VP}$**"** hence the interpretation of the target non-word 'pirdale' as a verb. In the case of noun sentences, the phonological phrase boundary occurred *after* the target word. Participants thus did not have access to prosodic information when they processed the target word. A post-hoc analysis showed that responses given before the end of the target word (before having access to prosodic boundary information) were mostly verb responses (the most standard syntactic construction being article+noun+verb), and that subjects revised their interpretation upon hearing the prosodic boundary placed after the target word (with a majority of noun responses for responses given after the end of the target word).

These data show that adults are able to build a syntactic skeleton even for sentences for which they do not know the content words. Therefore, 18-month-old infants, who have been shown to already know much about both the phrasal prosody of their native language, and their function words, might well be able to do the same. They would then be able to exploit this syntactic skeleton in order to facilitate their acquisition of the meaning of words, and of other aspects of the syntax of their native language.

Conclusion

To sum up the data presented in this chapter, we suggested that children might start to acquire the syntax of their native language by focussing on two sources of information which can be available to them very early on, namely phrasal prosody and function words. We showed that adults are capable of exploiting the presence of phonological phrase boundaries to constrain their on-line syntactic analysis of sentences (MILLOTTE ET AL, 2007, 2008). These results support the hypothesis that listeners compute a pre-lexical representation broken up into prosodic units, and that they use such representations in their analysis of the syntax of sentences. Since infants also process phrasal prosody, and are able to exploit phonological phrases to constrain lexical access (see e.g. GOUT ET AL. 2004), it is plausible that just like adults, they may also exploit phrasal prosody for syntactic analysis.

As regards function words, several studies have demonstrated that young children have knowledge of the function words of their mother tongue by the end of their first year (HALLÉ ET AL, 2008; SHAFER ET AL, 1998; SHI ET AL. 2006), and already associate articles with nouns before the age of 18 months (HÖHLE ET AL. 2004; SHI & MELANÇON, in press). In addition, we showed that they also associate pronouns with verbs by the age of 18 months (CAUVET ET AL. 2010), and are able to exploit the syntactic context of a new word to infer its syntactic category and guess its meaning by the age of 2 years (BERNAL et al., 2007).

Finally, we suggested that listeners (both adults and children) may construct a first-pass syntactic analysis, the syntactic skeleton, by relying on two sources of information simultaneously: prosodic boundaries, which coincide with syntactic boundaries, and function words that may be used to label these units. This hypothesis is supported by the results obtained in our final experiment with jabberwocky sentences (Millotte et al. 2006). Eighteen-month-olds seem to be in a situation similar to that experienced by the adult participants in our jabberwocky experiment: they have access to the function words of their mother tongue and are sensitive to phrasal prosody; they may thus be able to compute the 'syntactic skeleton'.

References

BERNAL, S., LIDZ, J., MILLOTTE, S., & CHRISTOPHE, A. Syntax constrains the acquisition of verb meaning. *Language Learning and Development, 3*, 325-341, 2007.

BERNAL, S., DEHAENE-LAMBERTZ, G., MILLOTTE, S., & CHRISTOPHE, A. Two-year-olds compute syntactic structure on-line. *Developmental Science,12,* 69-76, 2010.

BRUSINI, P., DEHAENE-LAMBERTZ, G. & CHRISTOPHE, A. Item-based or syntax? An ERP study of syntactic categorization in French-learning 2-year-olds. *Boston University Conference on Language Acquisition*, Boston (USA), 2009.

CAUVET, E., ALVES LIMISSURI, R., MILLOTTE, S., MARGULES, S. & CHRISTOPHE, A. What 18-month-old French-learning infants know about nouns and verbs. Poster presented at the *International Conference on Infant Studies*, Baltimore (USA), 2010.

CHEMLA, E., MINTZ, T. H., BERNAL, S., & CHRISTOPHE, A. Categorizing words using "Frequent Frames": What cross-linguistic analyses reveal about distributional acquisition strategies. *Developmental Science, 12*, 396-406, 2009.

CHRISTOPHE, A., GUASTI, M. T., NESPOR, M., DUPOUX, E., & VAN OOYEN, B. Reflections on phonological bootstrapping: its role for lexical and syntactic acquisition. *Language and Cognitive Processes, 12,* 585-612, 1997.

CHRISTOPHE, A., MILLOTTE, S., BERNAL, S., & LIDZ, J. Bootstrapping lexical and syntactic acquisition. *Language and Speech, 51*, 61-75, 2008.

CHRISTOPHE, A., GOUT, A., PEPERKAMP, S., & MORGAN, J. L. Discovering words in the continuous speech stream: The role of prosody. *Journal of Phonetics, 31*, 585-598, 2003.

CHRISTOPHE, A., NESPOR, M., GUASTI, M. T., & VAN OOYEN, B. Prosodic structure and syntactic acquisition: the case of the head-direction parameter. *Developmental Science, 6*, 211-220, 2003.

GERKEN, L., JUSCZYK, P. W., & MANDEL, D. R. When prosody fails to cue syntactic structure: 9-month-olds' sensitivity to phonological versus syntactic phrases. *Cognition, 51*, 237-265, 1994.

GERVAIN, J., NESPOR, M., MAZUKA, R., HORIE, R., & MEHLER, J. Bootstrapping word order in prelexical infants: A Japanese-Italian cross-linguistic study. *Cognitive Psychology, 57*, 56-74, 2008.

GILLETTE, J., GLEITMAN, H., GLEITMAN, L., & LEDERER, A. Human simulations of vocabulary learning. *Cognition, 73*, 135-176, 1999.

GLEITMAN, L. The structural sources of verb meanings. *Language Acquisition, 1*, 3-55, 1990.

GLEITMAN, L., & WANNER, E. The state of the state of the art. In E. WANNER & L. GLEITMAN (Eds.), *Language acquisition: The state of the art* (pp. 3-48). Cambridge UK: Cambridge University Press, 1982.

GOUT, A., CHRISTOPHE, A., & MORGAN, J. Phonological phrase boundaries constrain lexical access: II. Infant data. *Journal of Memory and Language, 51*, 548-567, 2004.

HALL, D., WAXMAN, S., BRÉDART, S., & NICOLAY, A.-C. Preschoolers' use of form class cues to learn descriptive proper names. *Child Development, 74*, 1547-1560, 2003.

HALLÉ, P., DURAND, C., & DE BOYSSON-BARDIES, B. Do 11-month-old French infants process articles? *Language and Speech, 51*, 45-66, 2008.

HOCHMANN, J.-R., ENDRESS, A. D., & MEHLER, J. Word frequency as a cue for identifying function words in infancy. *Cognition, 115*, 2010.

HÖHLE, B., WEISSENBORN, J., KIEFER, D., SCHULZ, A., & SCHMITZ, M. Functional elements in infants' speech processing: The role of determiners in the syntactic categorization of lexical elements. *Infancy, 5*, 341-353, 2004.

KEDAR, Y., CASASOLA, M., & LUST, B. Getting there faster: 18- and 24-month-old infants' use of function words to determine reference. *Child Development, 77*, 325-338, 2006.

MILLOTTE, S., WALES, R., & CHRISTOPHE, A. Phrasal prosody disambiguates syntax. *Language and Cognitive Processes, 22*, 898-909, 2007.

MILLOTTE, S., RENE, A., WALES, R., & CHRISTOPHE, A. Phonological phrase boundaries constrain on-line syntactic analysis. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 34*, 874-885, 2008.

MILLOTTE, S., WALES, R., DUPOUX, E., & CHRISTOPHE, A. The role of prosodic cues and function words in syntactic processing and acquisition. Paper presented at the *Infant Conference on Infant Studies*, Kyoto (Japon), 2006.

MILLOTTE, S., MARGULES, S., DUTAT, M., BERNAL, S. & CHRISTOPHE, A. (in press). Phrasal prosody constrains word segmentation in French 16-month-olds. *Journal of Portuguese Linguistics.*

MINTZ, T. H. Frequent frames as a cue for grammatical categories in child-directed speech. *Cognition, 90*, 91-117, 2003.

MORGAN, J. L. *From simple input to complex grammar*. Cambridge Mass: MIT Press, 1986.

MORGAN, J. L., & DEMUTH, K. Signal to Syntax: an overview. In J. L. MORGAN & K. DEMUTH (Eds.), *Signal to Syntax: Bootstrapping from speech to grammar in early acquisition* (pp. 1-22). Mahwah, NJ: Lawrence Erlbaum Associates, 1996.

NAZZI, T., NELSON, D. G. K., JUSCZYK, P. W., & JUSCZYK, A. M. Six-month-olds' detection of clauses embedded in continuous speech: effects of prosodic well-formedness. *Infancy, 1*, 123-147, 2000.

NESPOR, M., GUASTI, M. T., & CHRISTOPHE, A. Selecting word order: the Rhythmic Activation Principle. In U. Kleinhenz (Ed.), *Interfaces in Phonology* (pp. 1-26). Berlin: Akademie Verlag, 1996.

NESPOR, M., & VOGEL, I. *Prosodic Phonology*. Dordrecht: Foris, 1986.

SHAFER, V. L., SHUCARD, D. W., SHUCARD, J. L., & GERKEN, L. An electrophysiological study of infants' sensitivity to the sound patterns of English speech. *Journal of Speech, Language and Hearing Research, 41*, 874-886, 1998.

SHATTUCK-HUFNAGEL, S., & TURK, A. E. A prosody tutorial for investigators of auditory sentence processing. *Journal of Psycholinguistic Research, 25*, 193-247, 1996.

SHI, R., CUTLER, A., WERKER, J., & CRUICKSHANK, M. Frequency and form as determinants of functor sensitivity in English-acquiring infants. *Journal of the Acoustical Society of America, 119*, EL61-EL66, 2006.

SHI, R., & GAUTHIER, B. Recognition of function words in 8-month-old French-learning infants. *Journal of the Acoustical Society of America, 117*, 2426-2427, 2005.

SHI, R., & MELANÇON, A. Syntactic categorization in French-learning infants. *Infancy*, in press, 2010.

SHI, R., MORGAN, J. L., & ALLOPENNA, P. Phonological and acoustic bases for earliest grammatical category assignment: a cross-linguistic perspective. *Journal of Child Language, 25*, 169-201, 1998.

SANTELMANN, L. M., & JUSCZYK, P. W. Sensitivity to discontinuous dependencies in language learners: evidence for limitations in processing space. *Cognition, 69*, 105-134, 1998.

SODERSTROM, M., SEIDL, A., KEMLER NELSON, D. G., & JUSCZYK, P. W. The prosodic bootstrapping of phrases: Evidence from prelinguistic infants. *Journal of Memory and Language, 49*, 249-267, 2003.

SODERSTROM, M., WHITE, K. S., CONWELL, E., & MORGAN, J. L. Receptive grammatical knowledge of familiar content words and inflection in 16-month-olds. *Infancy, 12*, 1-29, 2007.

WAXMAN, S., LIDZ, J., BRAUN, I. E., & LAVIN, T. Twenty four-month-old infants' interpretations of novel verbs and nouns in dynamic scenes. *Cognitive Psychology, 59*, 67-95, 2009.

ZANGL, R., & FERNALD, A. Increasing flexibility in children's online processing of grammatical and nonce determiners in fluent speech. *Language Learning and Development, 3*, 199-231, 2007.

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