

L'acquisition précoce de la syntaxe.

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Le langage: un système *productif*

l'unité de sens est le mot (ou morphème)

- le sens d'un *mot* est arbitraire

‘coquecigrue’

50 000 à 100 000

- le sens d'une *phrase* est calculé à partir du sens des mots qui la composent

‘Le livre racontait l'histoire d'un chat grincheux qui avait mordu un facteur.’

infini

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infini

des règles complexes...

... partagées par tous les locuteurs
d'une langue...



‘Pierre a dit à Paul qu’il partirait demain’

des règles complexes...

... partagées par tous les locuteurs
d'une langue...



‘Pierre a dit à Paul qu’il partirait demain’



‘Il a dit à Paul que Jacques partirait demain’

des règles complexes...

... partagées par tous les locuteurs
d'une langue...

← 'Pierre a dit à Paul qu'il partirait demain'

↖ 'Il a dit à Paul que Jacques partirait demain'

↖ 'Le candidat qu'il a vu hier n'a pas plu à Pierre'

des règles complexes...

... partagées par tous les locuteurs
d'une langue...

‘Pierre a dit à Paul qu'**il** partirait demain’



Il a dit à Paul que Jacques partirait demain’



‘Le candidat qu'**il** a vu hier n'a pas plu à Pierre’



Principe C: * A c-commande B si le premier XP qui domine A contient B;

* un pronom ne peut pas c-commander son antécédant.

... et apprises très tôt par les enfants.

‘Il a mangé les crêpes quand Nounours était dans
la cuisine’

‘Quand il a mangé les crêpes, Nounours était dans
la cuisine’

Stephen Crain

=> certaines propriétés du langage sont *innées*
(argument de la ‘pauvreté du stimulus’)

L'argument de la 'pauvreté du stimulus'

- les calculs syntaxiques sont complexes et dans une grande mesure arbitraires;
 - tous les adultes parlant une même langue partagent des intuitions communes;
 - pour apprendre ces calculs, il faudrait avoir accès à une information riche et détaillée (représentation sémantique exacte du sens de la phrase);
 - or, les enfants aussi jeunes qu'on puisse les tester partagent les mêmes intuitions que les adultes;
- => certaines propriétés du langage sont *innées*

D'autres faits:

1. le langage est spécifique à l'homme...

- tous les êtres humains parlent;
- aucune autre espèce ne possède un système de communication *productif* ('langage' des abeilles, etc...);
- toutes les tentatives d'apprendre une langue humaine à d'autres espèces ont échoué (ex: langue des signes à des chimpanzés).

D'autres faits:

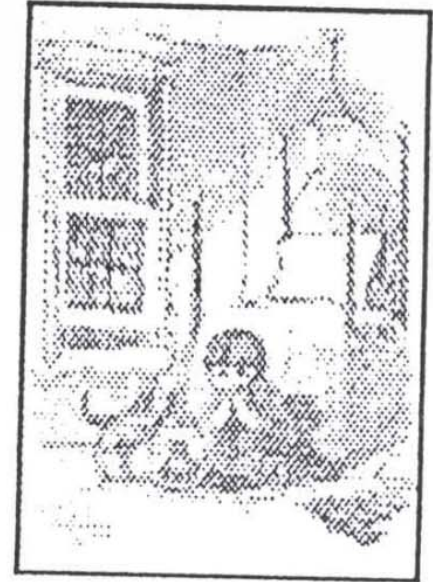
2. le langage est décorrélé de l' 'intelligence'

- on peut fonctionner normalement mais avoir un déficit spécifique pour le langage (enfants dysphasiques; dyslexiques)
- on peut avoir un retard mental mais maîtriser le langage de façon quasiment normale (syndrome de Williams)

F

WMS age 17, Full Scale IQ = 50

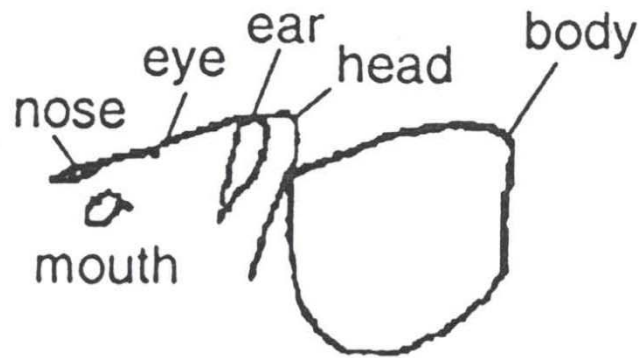
Once upon a time when it was dark at night...the boy had a frog. The boy was looking at the frog...sitting on the chair, on the table, and the dog was looking through...looking up to the frog in a jar. That night he slept and slept for a long time, the dog did. But, the frog was not gonna go to sleep. And when the frog went out...the boy and the dog were still sleeping. The next morning it was beautiful in the morning. It was bright and the sun was nice and warm. Then suddenly when he opened his eyes...he looked at the jar and then suddenly the frog was not there. The jar was empty. There was no frog to found (whispered).



DNS age 18, Full Scale IQ = 55

The frog is in the jar. The jar is on the floor. The jar on the floor. That' s it. The stool is broke. The clothes is laying there.

Elephant drawing



Elephant description

And what an elephant is it is one of the animals. And what the elephant does, it lives in the jungle. It can also live in the zoo. And what it has, it has long gray ears, fan ears, ears that can blow in the wind. It has a long trunk that can pick up grass, or pick up hay... If they're in a bad mood it can be terrible... If the elephant gets mad it could stomp; it could charge. Sometimes elephants can charge. They have long tusks. You don't want an elephant as a pet. You want a cat or a dog or a bird...

D'autres faits:

3. réinventer le langage: les 'créoles'

- le 'pidgin': élaboré pour communiquer entre adultes de langues différentes; pas de conjugaisons, d'articles, etc...
- le 'créole': inventé par les enfants qui apprennent un pidgin comme langue maternelle; rajoutent conjugaisons, articles, etc... ('créole hawaïen', 1900)
- exemple de 'créolisation': les langues des signes:
en France, 1780, abbé de l'Epée
au Nicaragua, 1980

Le langage est inné...

... mais, qu'est-ce qui est inné?

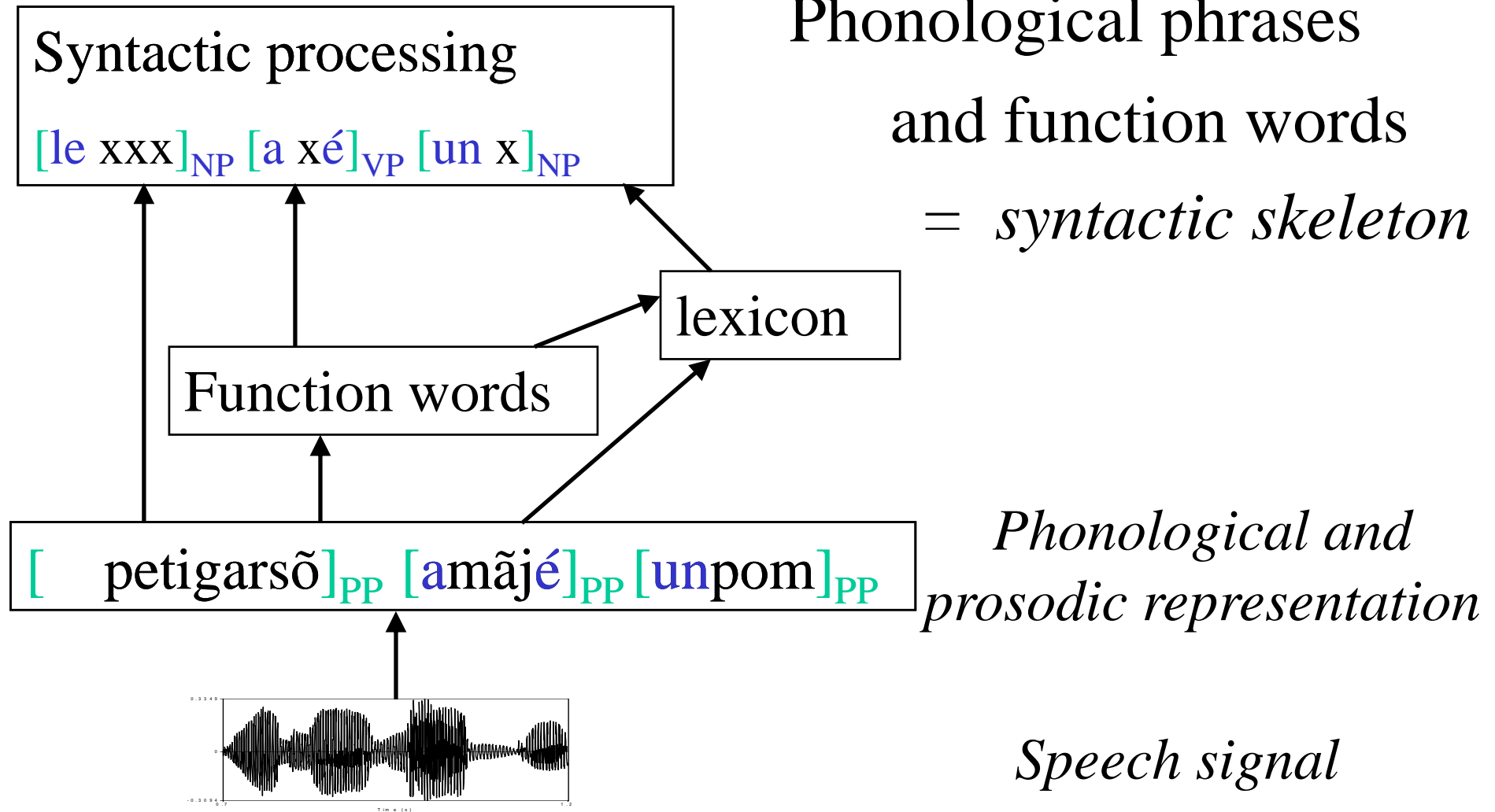
- Un mécanisme d'apprentissage spécialisé.
- Consensus: il existe une pré-disposition à acquérir les langues humaines;
Débat: quelle est la nature de cette pré-disposition? (Elman et al. 1996; Fitch, Hauser & Chomsky, 2002)
- ne peut être inné que ce qui est partagé par toutes les langues du monde
=> la *Grammaire Universelle*
- tout le reste doit *nécessairement* être appris: les mots, la phonologie, les propriétés syntaxiques spécifiques aux langues.
- Capacité à effectuer des calculs récursifs (Fitch et al.), théorie de l'esprit (Tomasello), capacité à coopérer (Tomasello)

‘Initialiser’ l’acquisition du langage

- Pour acquérir chaque partie du langage, la phonologie, le lexique (dictionnaire mental), la syntaxe, la sémantique, les bébés bénéficieraient de connaissances dans les autres parties;
- e.g. lexique utile pour apprendre la syntaxe, structure syntaxique utile pour apprendre le sens des mots (Gleitman et al. 1990)
- Trouver des sources d’information disponibles très tôt:

Prosodie phrasale }
Mots grammaticaux } => *squelette syntaxique*

Model of processing and acquisition

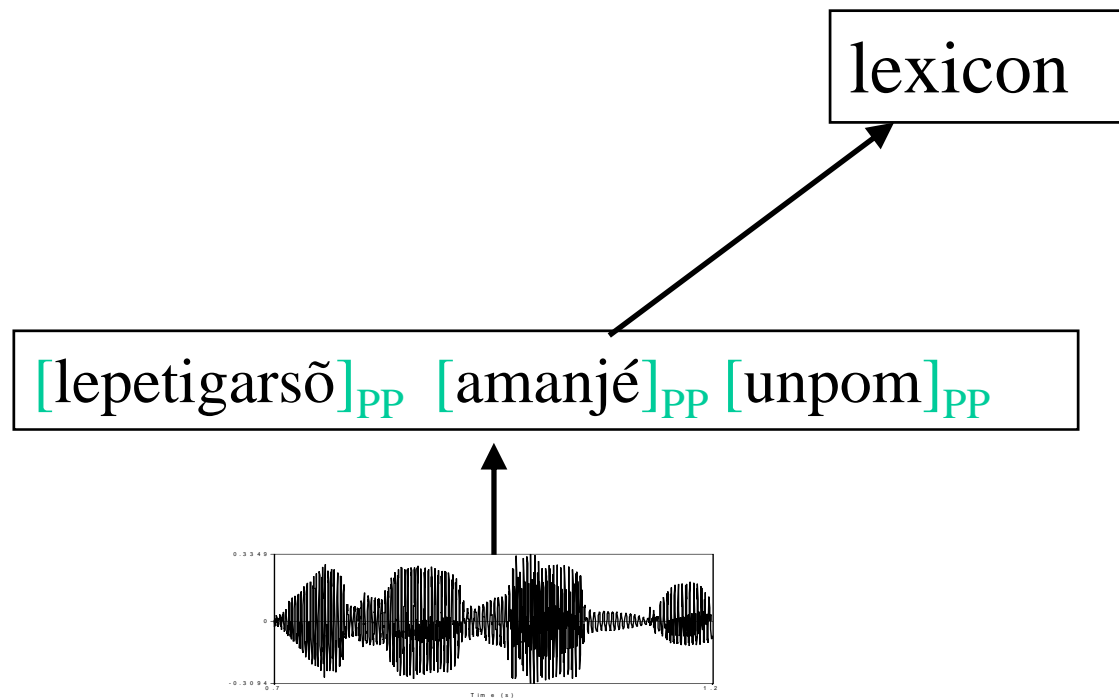


“le petit garçon a mangé une pomme”

Phrasal prosody is acquired early:

- Many experiments show that young infants react to the disruption of prosodic units:
 - 4.5-month-olds perceive intonational phrase boundaries, e.g. Kemler-Nelson, Hirsh-Pasek, Jusczyk & Cassidy, 1989; ...
 - 9-month-olds perceive phonological phrase boundaries, e.g. Gerken, Jusczyk, & Mandel, 1994;
- Well-formed prosodic units also enhance memorization:
 - Nazzi, Nelson, Jusczyk & Jusczyk, 2000;
Soderstrom, Seidl, Kemler Nelson & Jusczyk, 2003...

Phonological phrase boundaries constrain lexical access.



*Phonological and
prosodic representation*

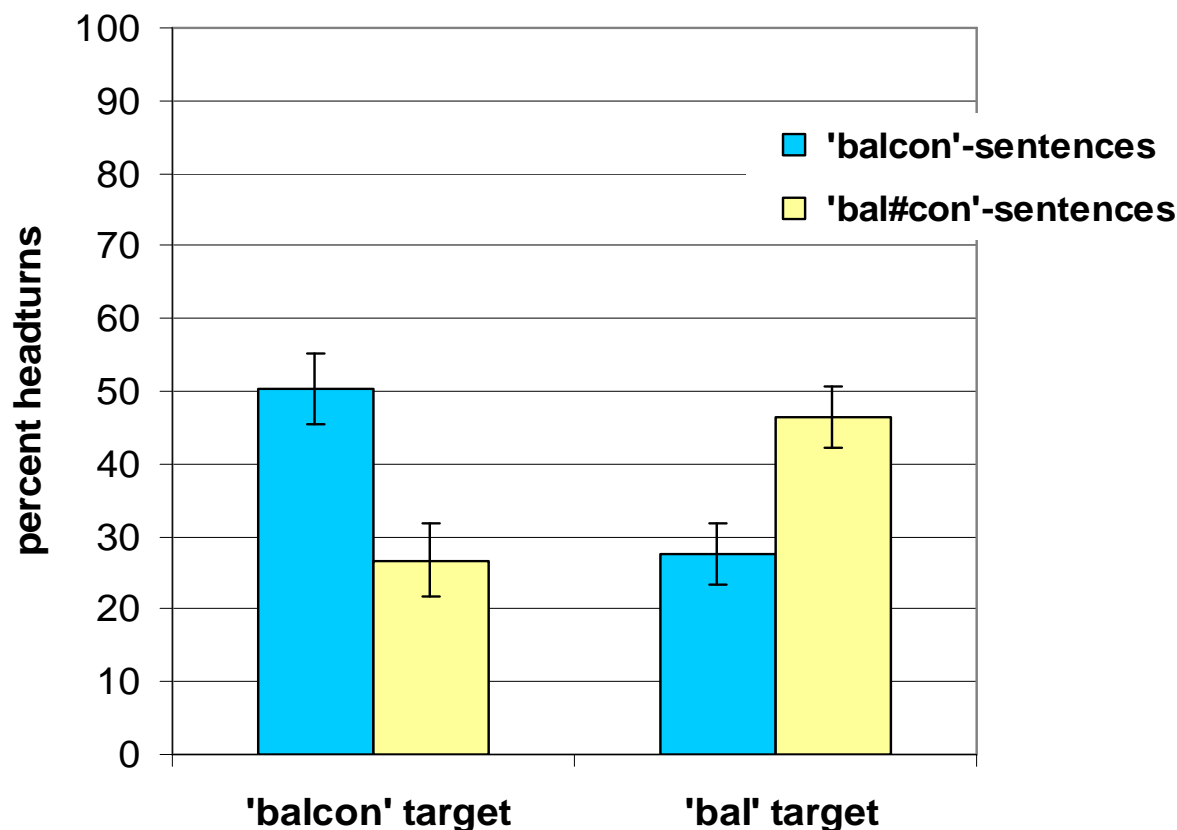
Speech signal

le petit garçon a mangé une pomme

Phonological phrase boundaries constrain lexical access:

Word detection,
French
16-month-olds.

Millotte et al. (2010) *Journal of Portuguese Linguistics*



[La rangée de *balcons*] [fait face au cloître] [du monastère]

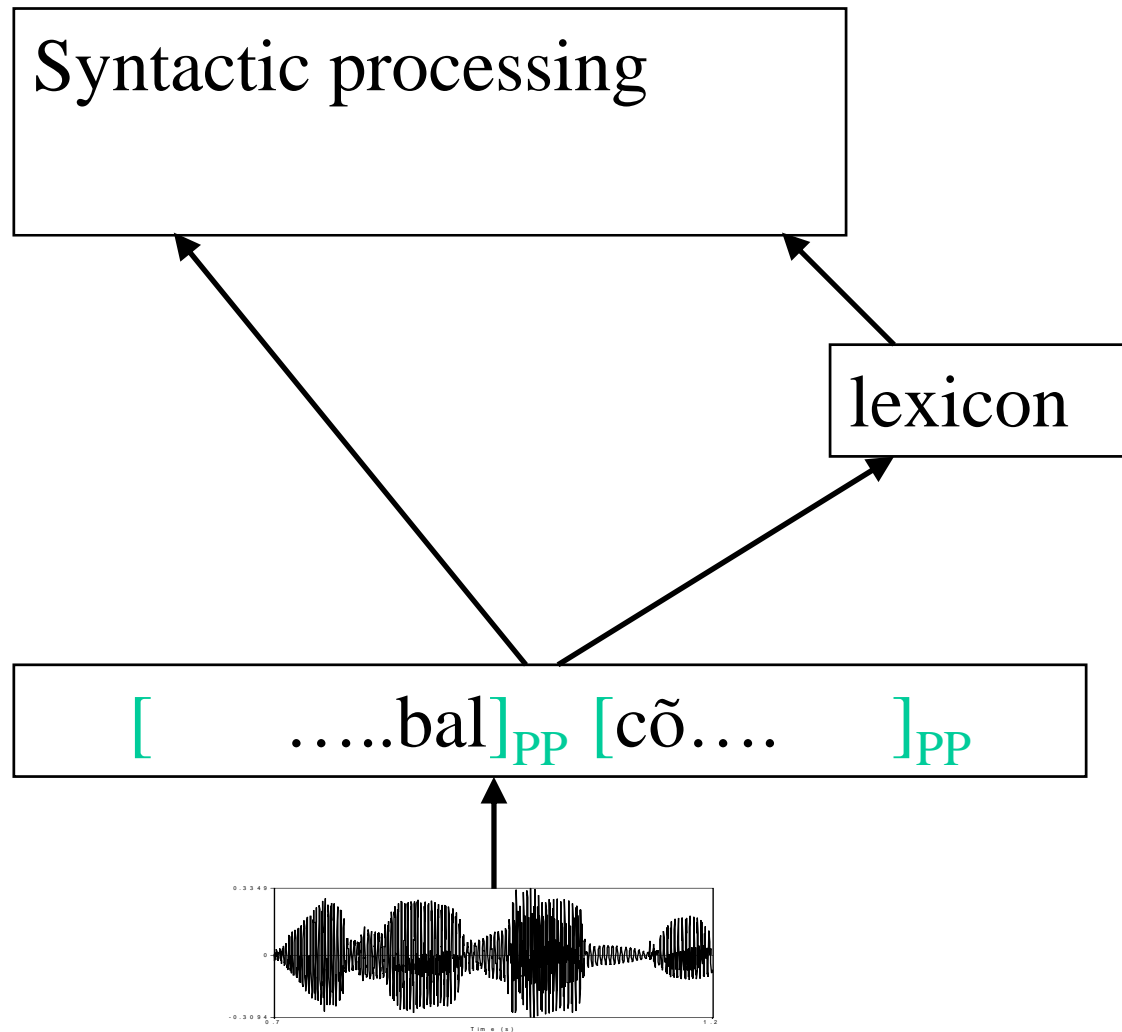


[La grande salle de *bal*] [*confère* un air solennel] [au château].



See also Gout, Christophe & Morgan (2004) *Journal of Memory and Language* for similar results in English.

Phonological phrase boundaries constrain lexical access ... and syntactic processing



- a phonological phrase boundary is interpreted on-line as a word boundary.

Phonological and prosodic representation

Speech signal

“la grande salle de bal confère un air solennel au château”

Use of phonological phrases in on-line syntactic processing (adults)

- Locally ambiguous sentences

- Verb :

[le petit chien]_{NP} [**mord** la laisse]_{VP} [qui le retient]...
(*the little dog **bites** the leash that restrains it*)



- Adjective :

[le petit chien **mort**]_{NP} [sera enterré demain]_{VP}...
(*the little **dead** dog will be buried tomorrow...*)

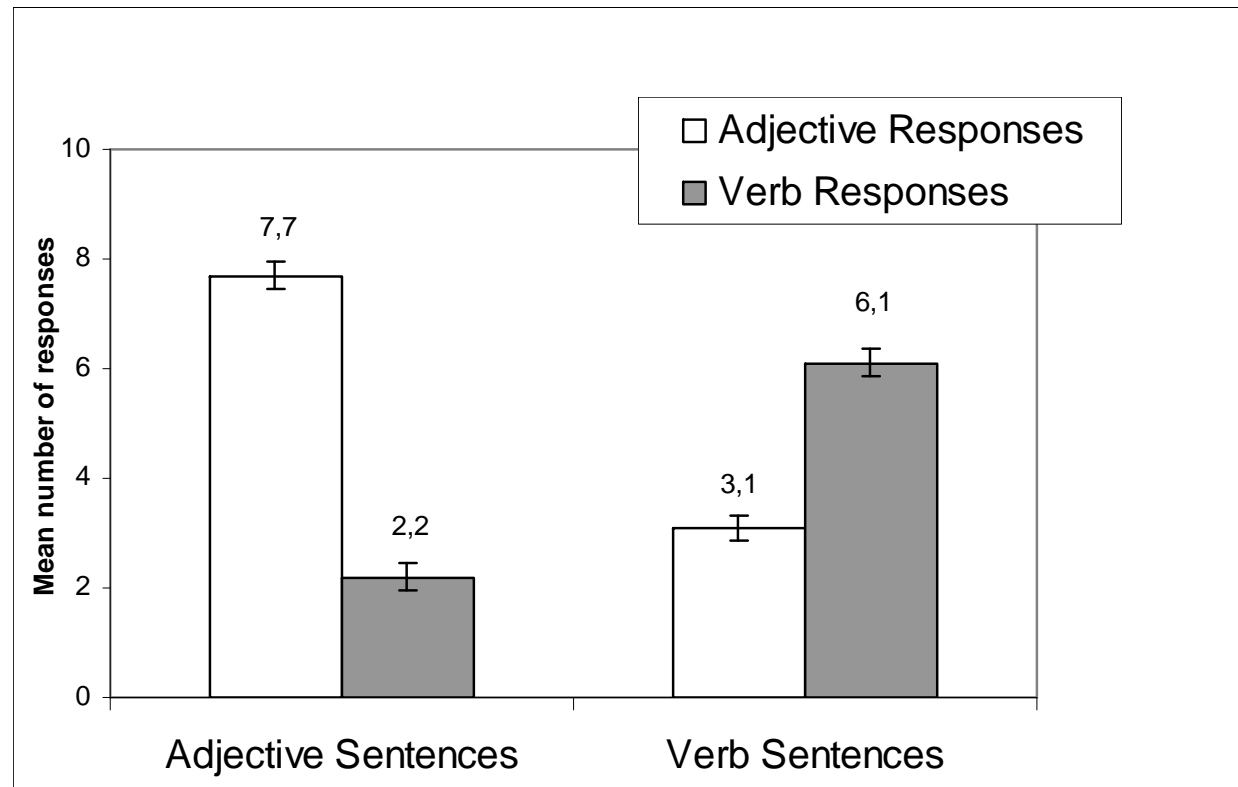


→ Sentence completion task:

listen to sentence beginning, freely complete sentence



Completion task



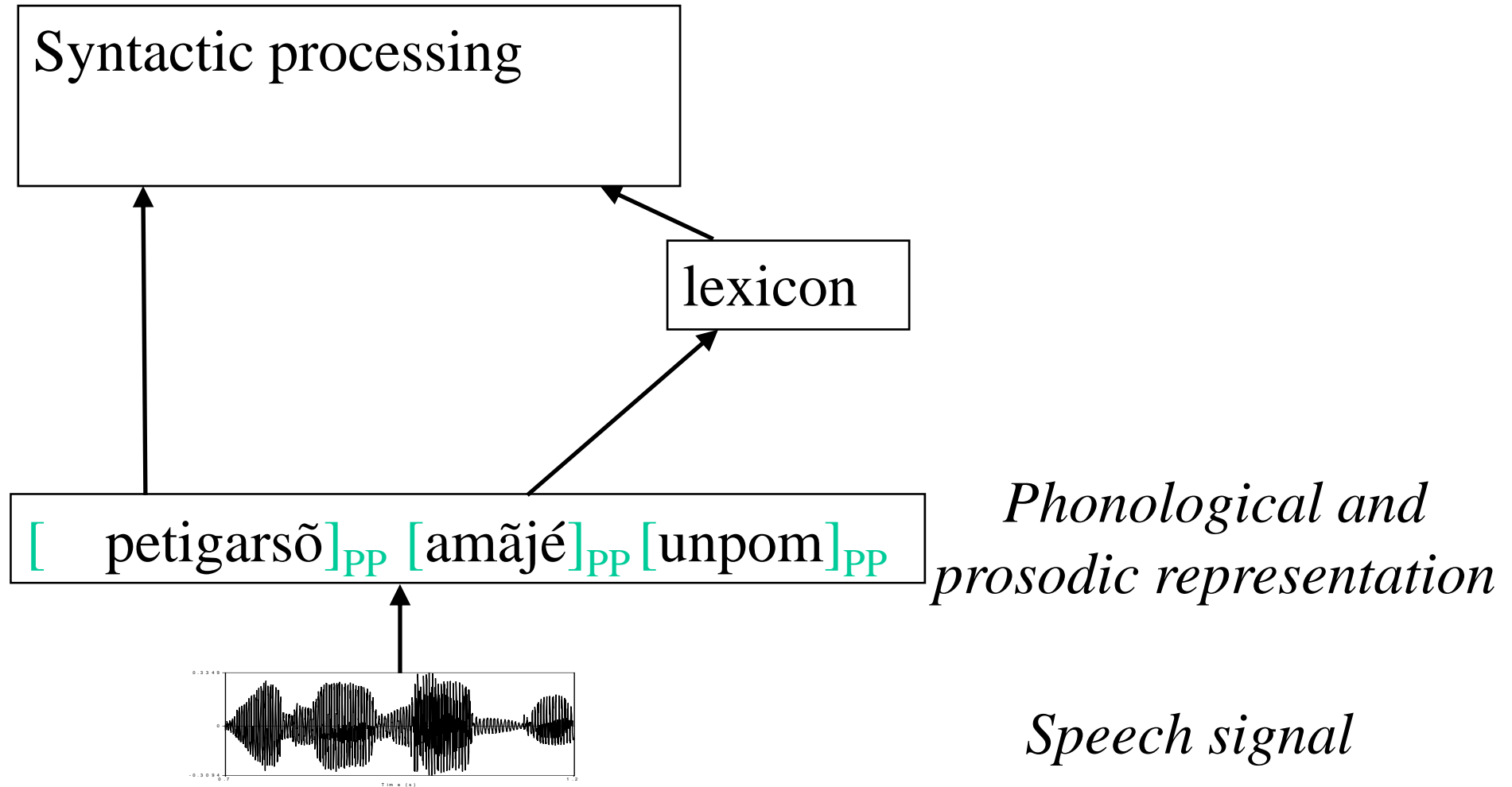
Millotte, Wales & Christophe (2007)
Language & Cognitive Processes

Millotte, René, Wales & Christophe (2008)
Journal of Experimental Psychology: Learning, Memory & Cognition

Adults exploit prosodic cues to constrain their syntactic analysis of sentences.

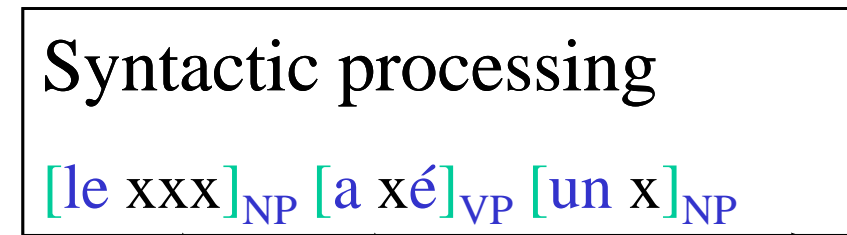
In addition these cues are exploited on-line (word-detection task)

Phonological phrase boundaries constrain lexical access and syntactic processing



“le petit garçon a mangé une pomme”

Special role for function words

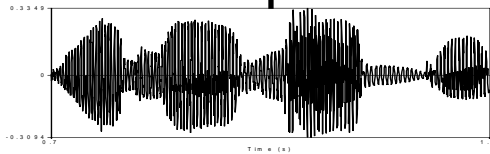


Phonological phrases
and function words

= *syntactic skeleton*



*Phonological and
prosodic representation*



Speech signal

“le petit garçon a mangé une pomme”

Function words:

- Can be acquired through a distributional analysis:
extremely frequent, short, located at prosodic unit edges.
e.g. Morgan, Shi & Allopenna (1996), Shi, Morgan & Allopenna, P. (1998).
- Are acquired early :
 - > 8- to 11-month-olds already know the most frequent function words of their language (Gerken, Landau, & Remez, (1990), Shafer, Shucard, Shucard & Gerken (1998), Shi & Gauthier, 2005, Shi, Werker & Cutler 2006), even though they may not have a fully detailed representation yet (Shi, Cutler, Werker & Cruickshank (2006))
 - > Infants exploit function words to find content words: Hallé, Durand & de Boysson-Bardies (2008) ; Shi & LePage (2008); e.g., after being familiarized with ‘des preuves’, look longer towards ‘preuves’ at test, but not after being familiarized with ‘ké preuves’ where ‘ké’ is not a function word in French.

Function words:

- Can be used to categorize content words:
 - 'je jaurime' -> 'jaurime' is a verb, refers probably to an action (*'it blicks'*)
 - 'la jaurime' -> 'jaurime' is a noun, refers probably to an object (*'the blick'*)
- * Höhle, Weissenborn, J. et al. (2004). *Infancy*: 16-month-old German infants: an article predicts a noun (although a pronoun does not yet predict a verb)
- * Shi & Melançon (2010) *Infancy*: 14-month-old French infants know the class of articles (not the one of pronouns).
- * Bernal, Lidz, Millotte & Christophe (2007) *Language Learning and Development*. French 2-year-olds map 'je dase' to an action, and 'la dase' to an object (see also Waxman et al. 2009 in English, Oshima-Takane et al. 2011 in Japanese).

Potential problems:

- 'je la mange' (*I eat it*), la+X but X is not a noun...

=> How accurate is syntactic processing at 2 years?

Evoked potential experiment relying on article/object pronoun ambiguity in French

Incorrect

*La fille prend **la mange**
(The girl takes the eat)

*Alors il **la fraise**
(Then he strawberries it)

Correct

Alors elle **la mange**
(Then she eats it)

La poule prend **la fraise**
*(The chicken takes the
strawberry)*

Verb

Noun

- No particular task: passive listening
- Use of known words only (from CDI questionnaire)
- To keep infants' attention focussed, the speaker is playing with toy objects (e.g. strawberry) while she tells a short story; only her face is visible when she utters the test sentences.

Example of Script

Sur ma table, je vois une girafe (N) qui va à l'école. Elle regarde (V) la poule

1. Donc la poule **la** **regarde** aussi.

(Correct)

2. Pourtant, elle **la girafe** très vite!

(Incorrect)

On my table, I see a giraffe (N) who goes to school. She looks (V) at the hen.

1. So the hen **looks** at her too.

(Correct)

2. However, she **giraffes** it really fast!

(Incorrect)



Method

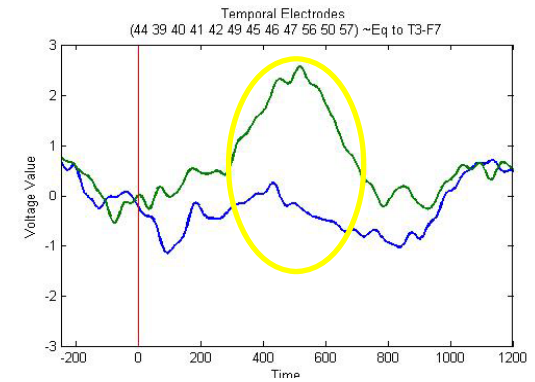
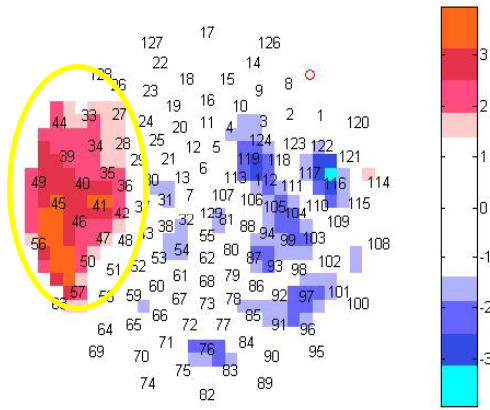
- ERP recording : EGI topographic system (128 electrodes)
- Collaboration with Ghislaine Dehaene-Lambertz



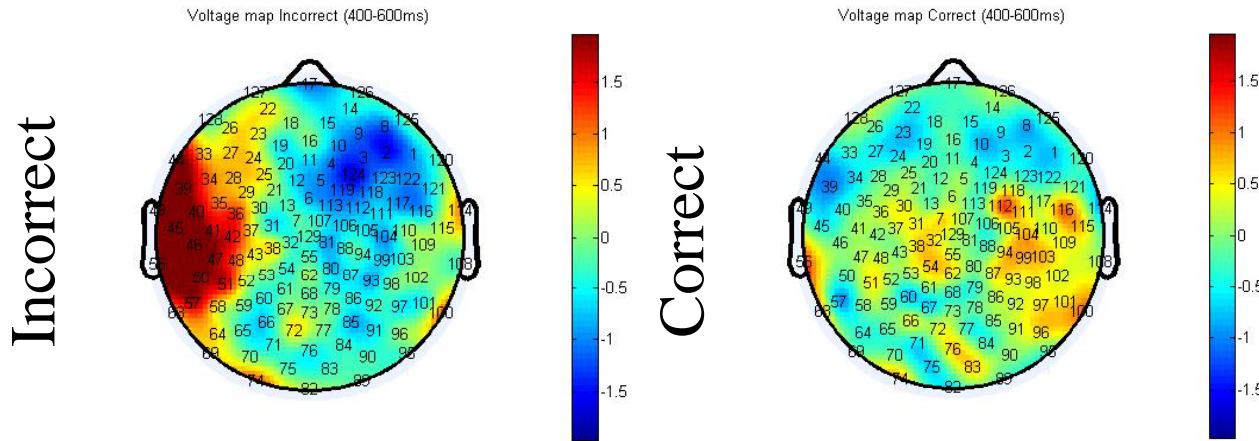
24-month-olds, known words

Bernal, Dehaene-
Lambertz, Millotte &
Christophe (2010).
Developmental Science.

Incorrect-Correct



la mange



450-650 ms

| Incorrect | Correct | |
|--|--|------|
| *La fille prend la mange <i>(The girl takes the eat)</i> | Alors elle la mange <i>(Then she eats it)</i> | verb |
| *Alors il la fraise <i>(Then he strawberries it)</i> | La poule prend la fraise <i>(The chicken takes the strawberry)</i> | noun |

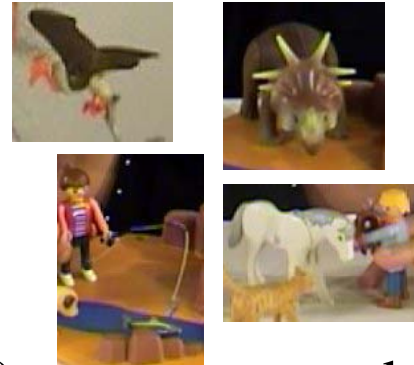
Toddlers compute syntactic expectations on-line.

- 2-year-olds build on-line syntactic expectancies:
'je la' predicts a verb, whereas 'je prends la' predicts a noun;
Infants are not fooled by the article/object clitic homophony
- Toddlers do not simply react to transition probabilities between pairs of words: 'elle+la' OK, 'la+fraise' OK, '*elle la fraise'
- However, they could react to the probabilities of 3-word strings:
they may have heard 'il la mange' before, whereas '*elle la fraise'
has never been heard.

-> use newly-learnt words

Testing syntactic expectations with newly-learned words

- **Phase 1:** teach 4 new words:
- 2 nouns: touse, rane
- 2 verbs: dumer, pouner

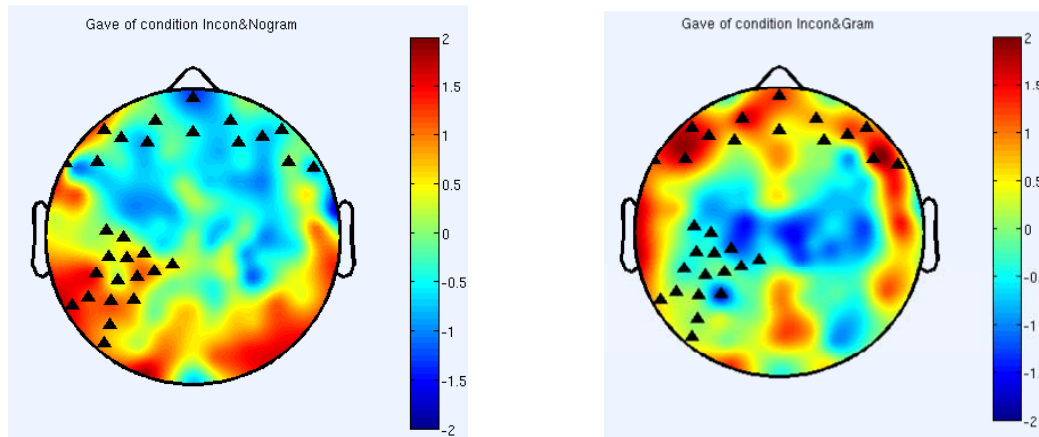
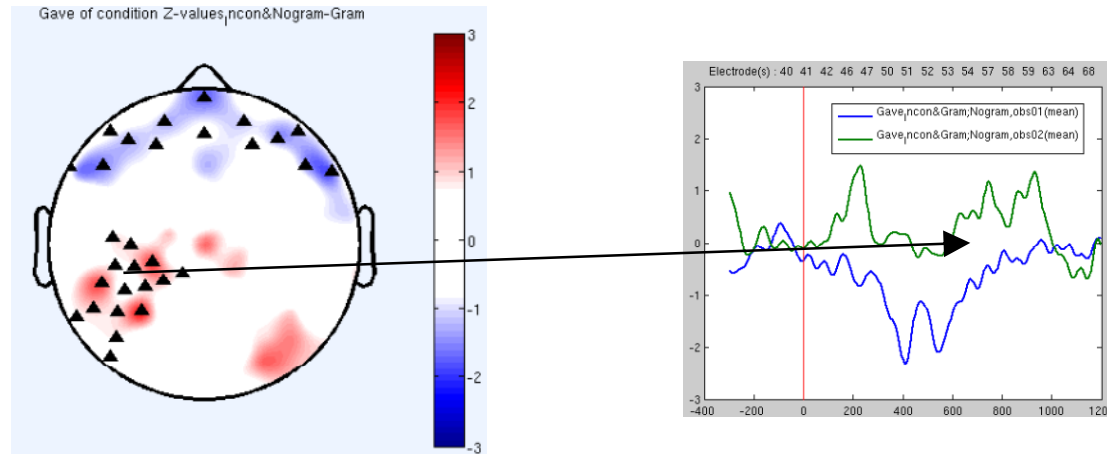


in an interactive play session (20mn), the new words are presented in many different syntactic structures, but not the test one: ‘le X’ (also well-known words: chien, chat, manger, donner)

- **Phase 2** (a week later): toddlers watch videos containing test sentences, with the target structure ‘le X’, where X is the target noun or verb

| Incorrect | | Correct | |
|-----------------------------|--|-----------------------------|------|
| *Marie prend le dume | | Alors elle le dume | verb |
| *Alors il le touse | | Martin voit le touse | noun |

24-month-olds, newly-learnt words



700-1000 ms

| Agrammatical | Grammatical | |
|--|--|-------------|
| <p>*Maintenant le dume est plus calme <i>Now the dume is calmer</i></p> | <p>Alors Martin le dume maladroitement <i>then Martin dumes it clumsily</i></p> | <p>verb</p> |
| <p>*Martin le touse le poisson <i>Martin tooses the fish</i></p> | <p>L'indien pousse le touse vers la fleur <i>the indian pushes the toose towards the flower</i></p> | <p>noun</p> |

Perrine Brusini (PhD thesis)

Brusini, Dehaene-Lambertz & Christophe (in preparation).

2-year-olds compute syntactic structure on-line.

- Newly-learnt words trigger an agrammaticality effect, just like well-known words.
- 2-year-olds compute syntactic structure on-line:
'je le' predicts a verb, whereas 'je prends le' predicts a noun;
and this is true even though the newly-learnt nouns and verbs were never heard before in either context.
- Toddlers were thus able to assign the newly-learnt items to the noun or verb category (based on the contexts they heard them in during the teaching phase), and were able to generalize to novel correct contexts.

=> How do toddlers learn noun and verb contexts?

Learning noun and verb contexts

- Hypothesis: contexts are learnt on the basis of a few known nouns and verbs;
- Toddlers managed to learn the meaning of a few highly frequent nouns and verbs representing concrete objects and actions;
- They group words representing objects together, and words representing actions together.
- To test it: we trained a model on a corpus of child-directed speech where a few nouns and verbs are categorized (e.g. 6 Nouns and 2 Verbs, 6N-2V; 12 Nouns and 4 Verbs, 12N-4V, etc). The others words remain uncategorized.

A model of Noun/Verb categorization

- The model collects trigram frequencies (strings of 3 words – e.g. ‘je la VERB’)
- At test, the model categorizes every not-too-frequent word from a test corpus that has not been seen before, by using their immediate contexts: e.g. ‘je la X’
the model selects the most frequent thing that occurred in this context, either a category (here, VERB) or in some cases a specific item.
- Two measures are computed for noun and verb responses :

-precision : $hits / (hits + FA)$

“when the model gives a noun response, is it correct or not?”

(high precision= lots of hits,
low precision = lots of FA)

- recall : $hits / (hits + misses)$

“how many times did the model fail to respond noun when it encountered a noun ?”

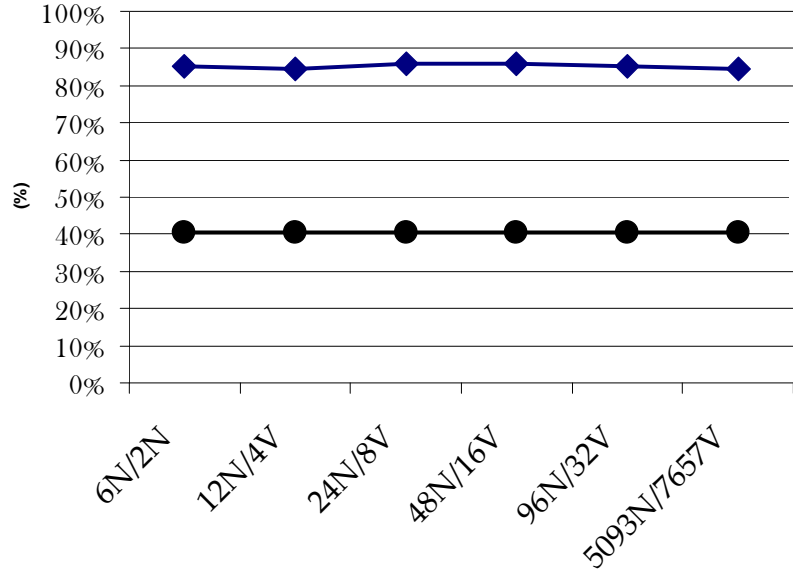
(high recall=lots of hits,
low recall = lots of misses)

Perrine Brusini (PhD thesis)

Brusini, Amsili, Chemla & Christophe (in preparation).

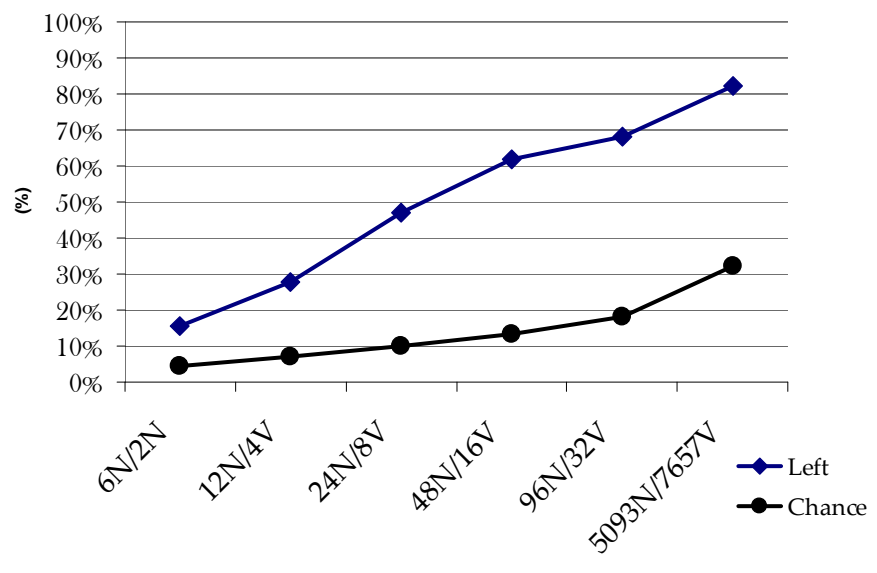
Noun

Precision



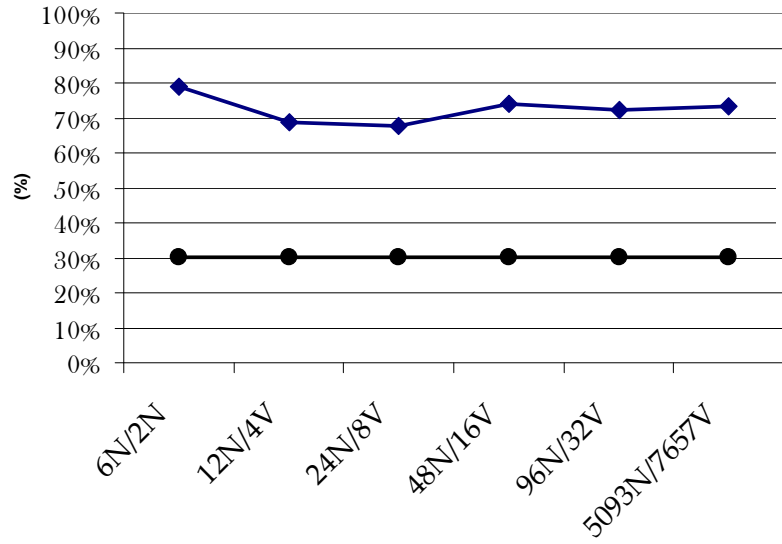
vocabulary size

Recall

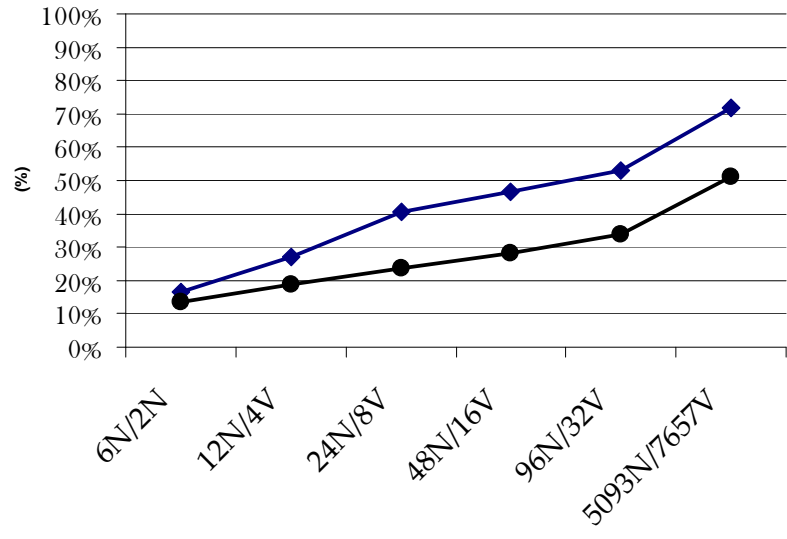


vocabulary size

Verb



vocabulary size



vocabulary size

Most frequent Noun contexts

- Trigrams = context size 2

| context | nb Noun | nb Verb | Model's response | translation |
|----------|---------|---------|------------------|-------------|
| # UN | 78 | 1 | Noun | # A |
| EST UN | 62 | 0 | Noun | IS A |
| VERB LE | 60 | 31 | Noun | VERB THE/IT |
| NOUN DE | 56 | 15 | Noun | NOUN OF/TO |
| VERB UN | 55 | 0 | Noun | VERB A |
| VERB DES | 52 | 0 | Noun | VERB SOME |
| # LE | 46 | 1 | Noun | # THE |
| # UNE | 45 | 0 | Noun | # A |
| DE LA | 41 | 4 | Noun | OF THE |
| VERB LA | 39 | 19 | Noun | VERB THE/IT |
| VERB LES | 34 | 12 | Noun | VERB THE/IT |
| # LA | 33 | 0 | Noun | # THE |
| VERB DU | 33 | 0 | Noun | VERB OF |
| à LA | 32 | 1 | Noun | TO THE |
| VERB UNE | 32 | 0 | Noun | VERB A |

Most frequent Verb contexts

- Trigrams = context size 2

| context studied | nb Noun | nb Verb | Model's response | translation |
|-----------------|---------|---------|------------------|-------------|
| # TU | 1 | 603 | Verb | # YOU |
| # ON | 0 | 225 | Verb | # WE |
| # JE | 0 | 187 | Verb | # I |
| # VERB | 3 | 110 | Verb | # VERB |
| # IL | 0 | 101 | Verb | # HE |
| # CA | 0 | 95 | Verb | # IT |
| QUE TU | 1 | 81 | Verb | THAT YOU |
| TU VERB | 5 | 58 | Verb | YOU VERB |
| ON VERB | 2 | 52 | Verb | WE VERB |
| TU AS | 6 | 46 | Verb | YOU HAVE |
| VERB PAS | 1 | 45 | Verb | VERB NOT |
| QU' IL | 0 | 45 | Verb | THAT HE |
| QU' ON | 0 | 44 | Verb | THAT WE |
| VERB VERB | 6 | 42 | Verb | VERB VERB |
| VERB I F | 60 | 31 | Noun | VERB THE/IT |

A model of Noun/Verb categorization

- * The model gets tricked by ambiguous function words – contrary to the 2-year-olds from the ERP experiment!
- * Indeed, the same model trained on bigrams performs almost as well for precision, with a better recall.
- * 2 conclusions from this:
 - * Listeners have more refined representations than the model (e.g., not just ‘VERB’, but what kind of verb it is).
 - in ‘je prends la mange’, (*I take the eat*) the sentence is wrong only because ‘prendre’ cannot take a verbal complement;
 - in contrast, ‘je veux la manger’ (*I want to eat it*) is perfectly all right.
 - * 2-year-olds already have these refined representations

A model of Noun/Verb categorization

- * There is enough information in small local contexts to categorize nouns and verbs (75% to 85% precision)
- * To do so it is not necessary to build function words categories; the frequency of these items is sufficient to highlight them
- * the precision is very good for all sizes of known vocabulary but the recall improves markedly with the number of known nouns and verbs during training
 - * note that from a language learner point of view, it is better to be accurate when you categorize new items than over-generalize too much
- * The model, although it performs extremely well already, still falls short of human toddlers performance.

How accurate exactly is human processing? jabberwocky with adults.

Method: simulate an 18-month-old with adults:
jabberwocky = intact phrasal prosody and function words, nonsense content words.

Abstract word detection task:

target: 'bamouler' (*to blick*) 'une bamoule' (*a blick*)

- targets are directly preceded by an unambiguous function word

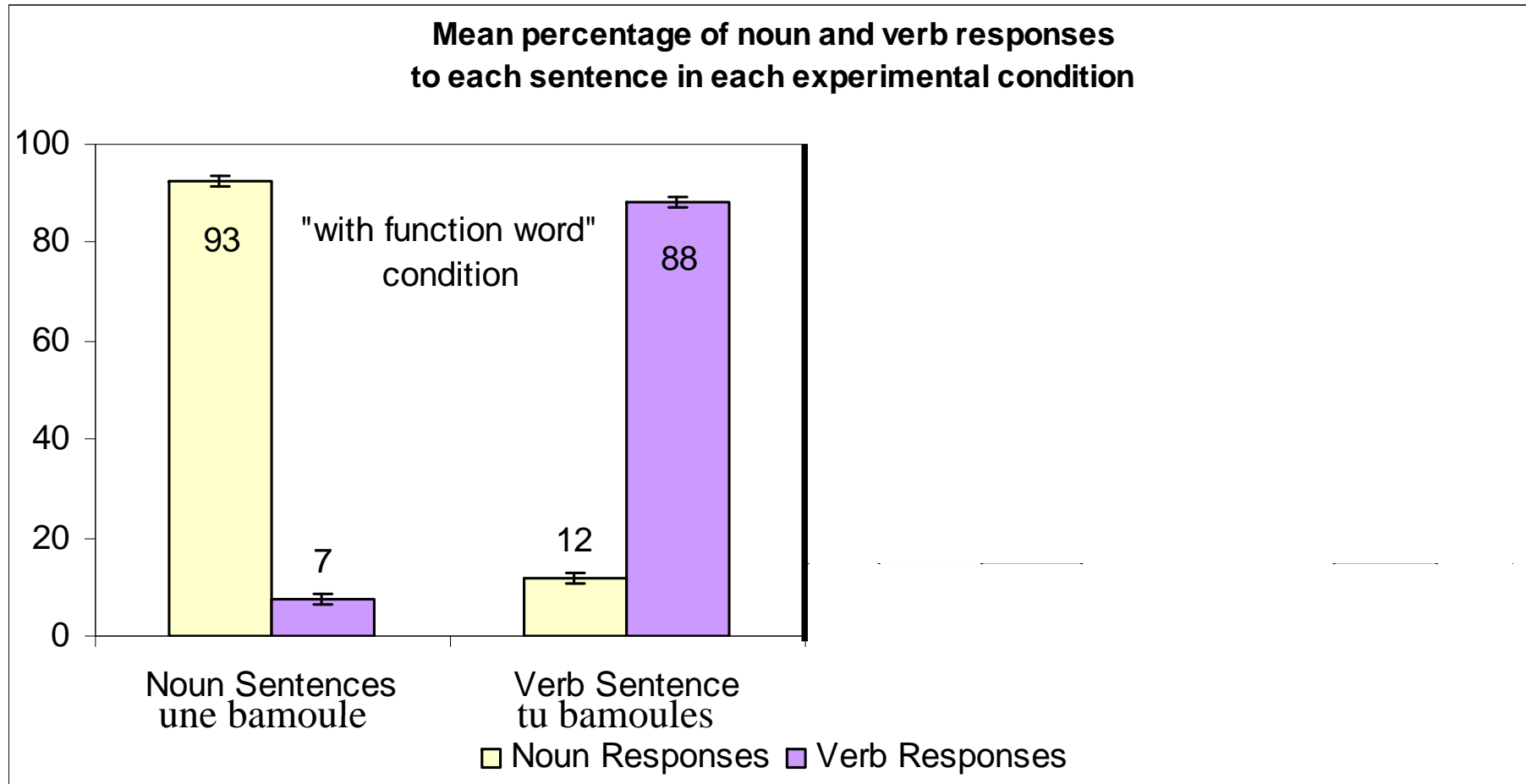


- Noun Sentence : [une bamoule] [dri se froliter dagou]
([une expo]_{NP} [doit se dérouler demain])



- Verb Sentence : [tu bamoules] [saman ti] [à mon ada]
([tu travailles]_{VP} [souvent trop] [à mon avis])

Results



Mean reaction time: 650ms (fast)

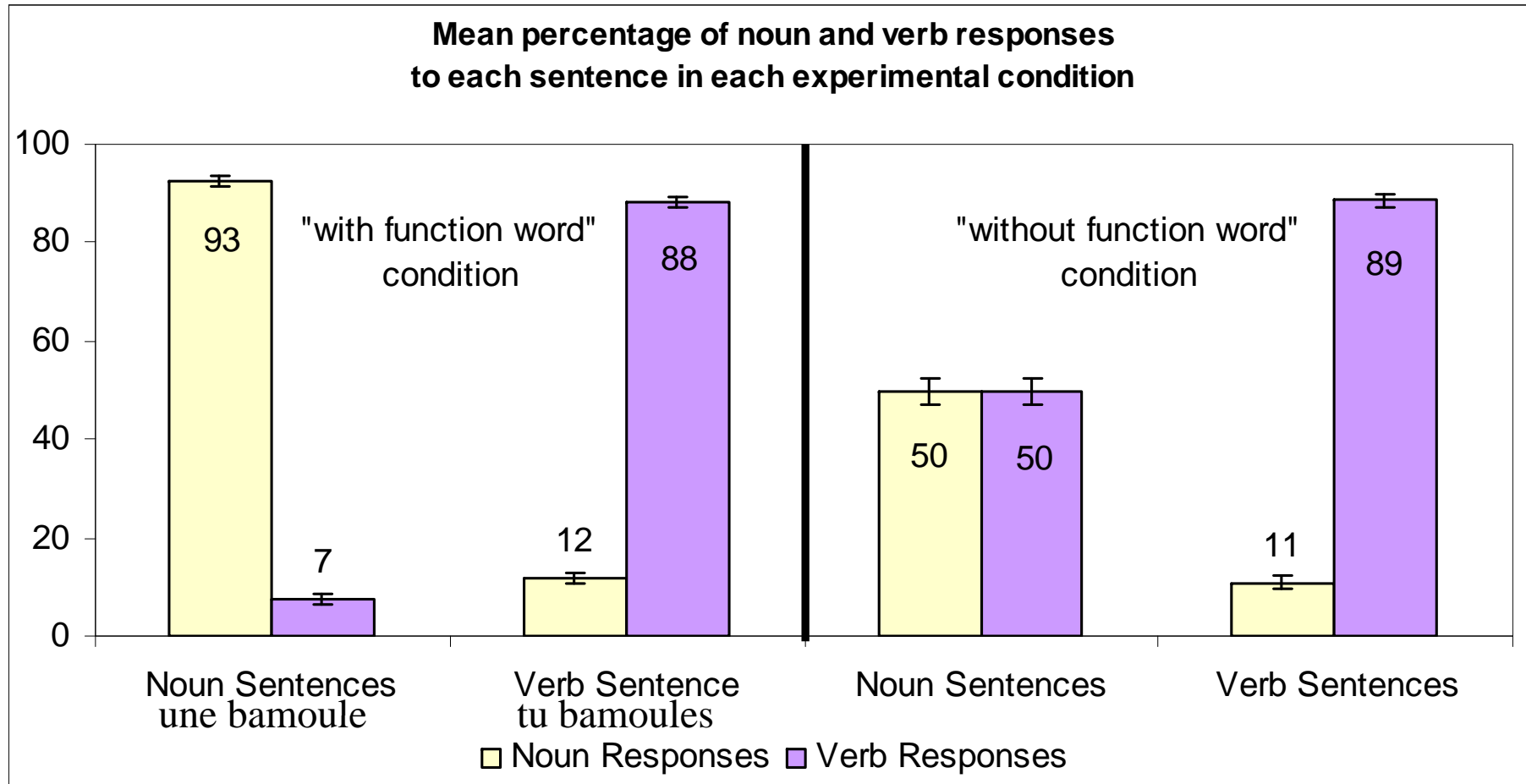
Millotte, S., Bernal, S., Dupoux, E., & Christophe, A. (in preparation).

Prosody and function words together

- Without function word : targets are not directly preceded by a function word (use of prosodic boundary)
 - Noun Sentence : [sa cramona bamoule] [camiche dabou]
([sa formidable expo]_{NP} [commence demain]_{VP})
 - Verb Sentence : [sa cramona] [bamoule muche]...
([sa camarade]_{NP} [travaille mieux]_{VP}...)

Abstract word detection task:

ex: 'bamouler' (*to blick*) 'une bamoule' (*a blick*)

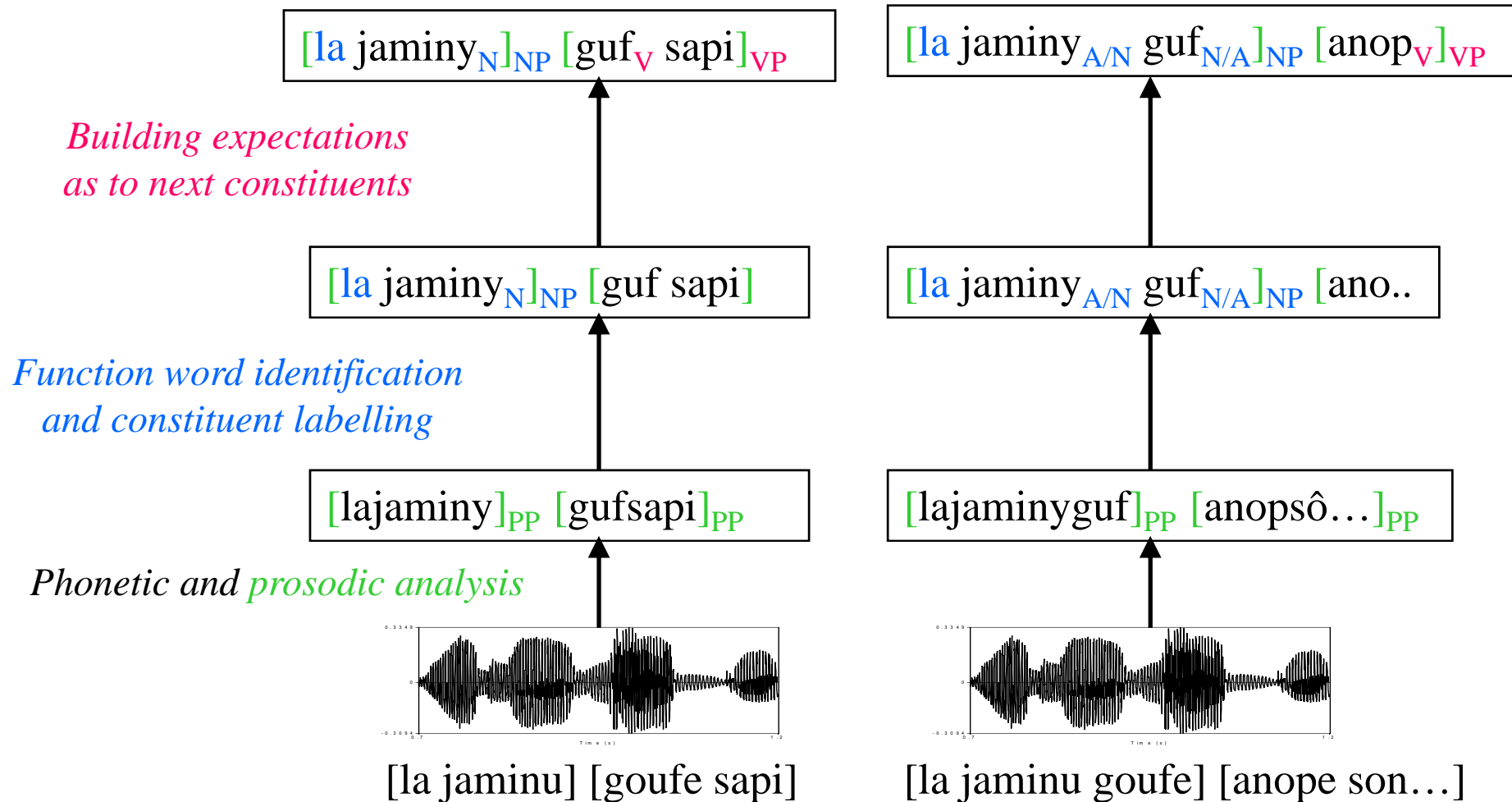


Mean reaction time: 650ms (fast)

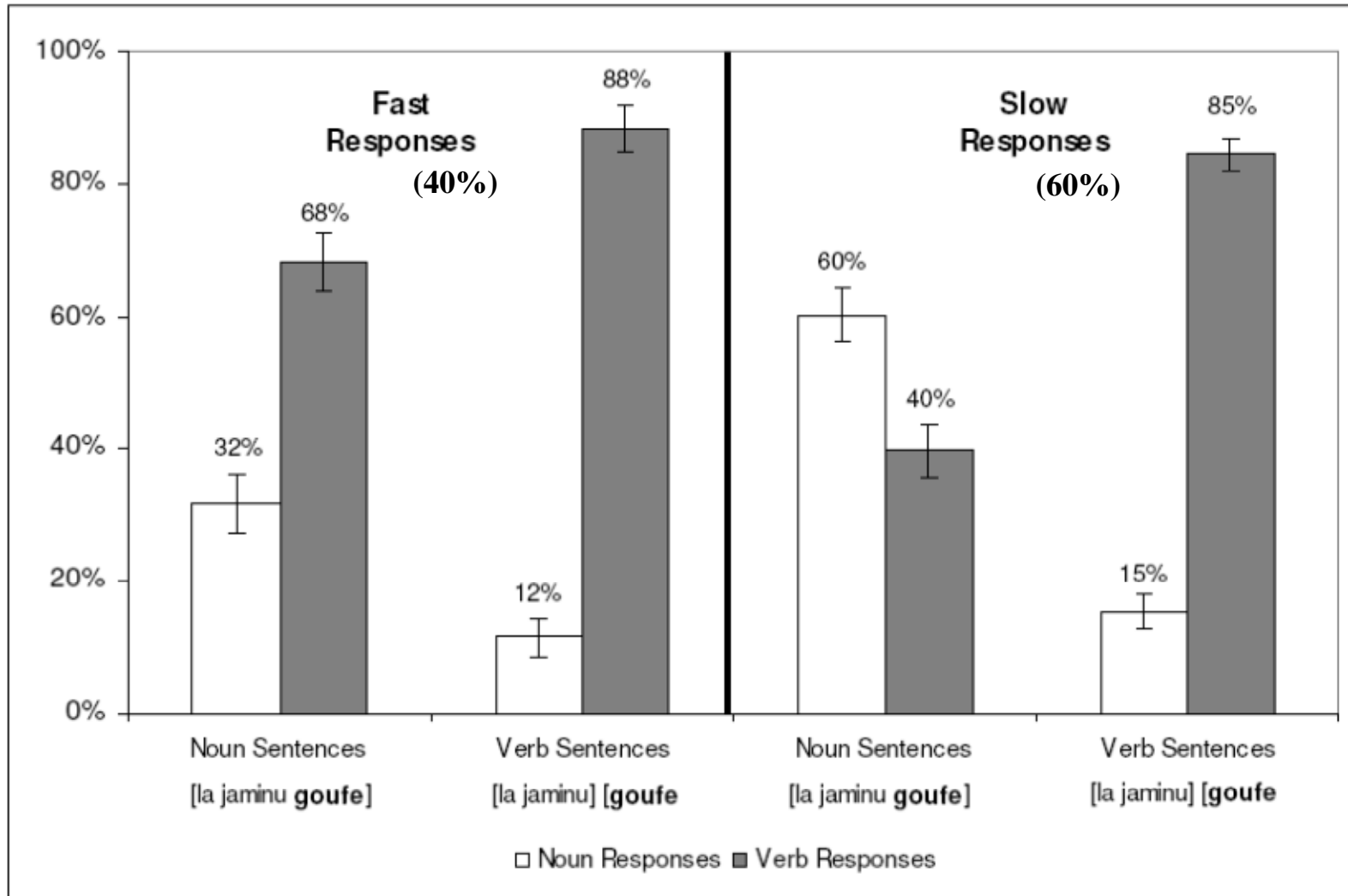
Millotte, S., Bernal, S., Dupoux, E., & Christophe, A. (submitted).
Syntactic parsing without a lexicon. *Cognition*.

Joint use of prosodic boundaries and function words.

Target non-word: goufe
(une goufe / goufer)



Analysis of fast responses (given before the end of the target word).

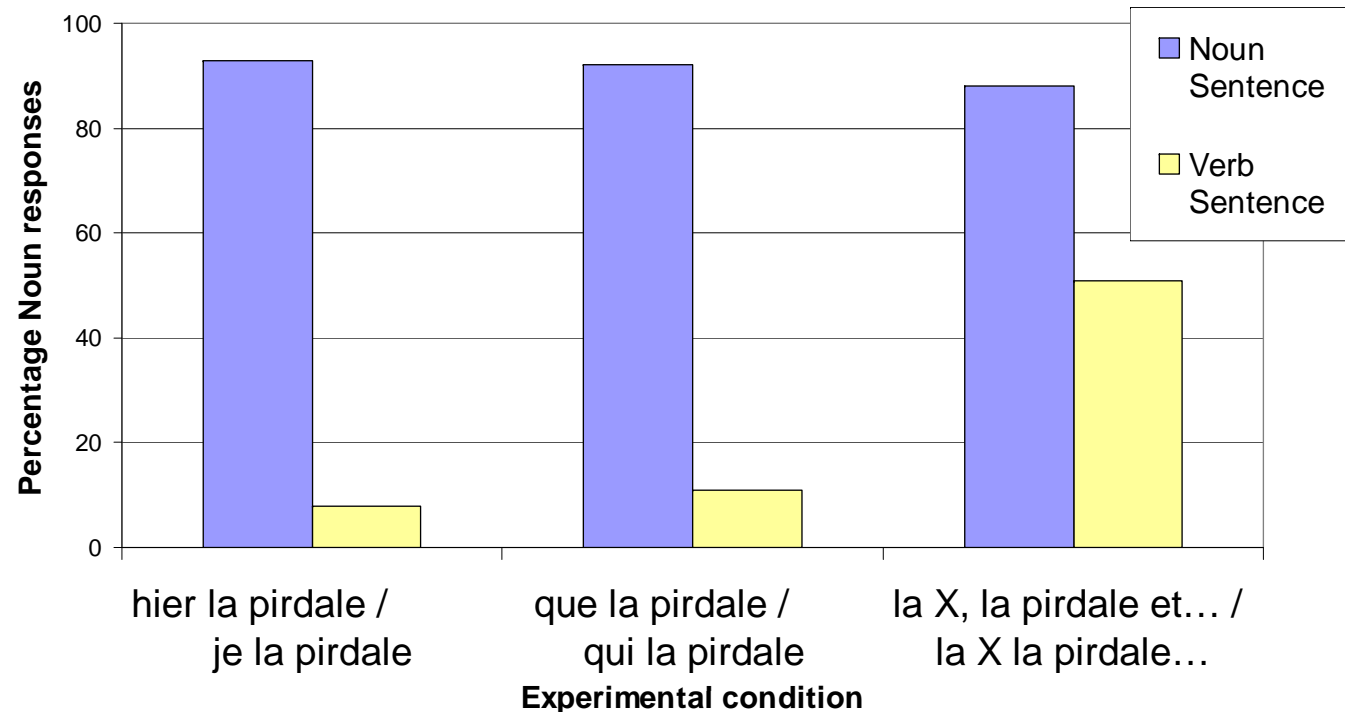


Before the prosodic boundary is heard: bias for verb responses;
after it: noun sentences switch to a bias for noun responses.

How do adults cope with ambiguous function words: la pirdale N? V?

Abstract word
detection task:
ex: 'pirdaler' (*to blick*)
'une pirdale' (*a blick*)

Cauvet, Millotte &
Christophe (in
preparation)



Je la pirdale_V (I blick_V it) // hier la pirdale_N (yesterday the blick_N...)

Le bamoule_N qui la pirdale_V (the dax_N who blicks_V it) //

Le bamoule_N que la pirdale_N muche (the dax_N whom the blick_N gorps...)

La bamoule_N la pirdale_V digument (the dax_N blicks_V it dithely)

La bamoule_N, la pirdale_N et le taruche muchent (the dax, the blick_N and...)

Adults and the syntactic skeleton

- * In all the contexts tested, adults were perfectly accurate, as soon as the information became available (for prosodic boundaries: just after the boundary was heard).
- * Even with ambiguous function words, adults showed perfect performance.

General conclusion

- Before the age of 18 months, infants adequately perceive phrasal prosody, and exploit it to constrain lexical access on-line;
- They know a lot about the function words of their language;
- They know the contexts in which nouns and verbs occur, and build on-line syntactic expectations.
- They may learn noun and verb contexts by computing common contexts for a few concrete nouns and verbs.
- Adults made to ‘simulate’ an 18-month-old are near-perfect in their processing of jabberwocky sentences.

- *Syntactic skeleton:*

[le XXX]_{NP} [a xé]_{VP} [une X]_{NP}

maybe around 14-18 months...

=> potentially enough information to constrain the acquisition of word meanings (nouns vs verbs, different classes of verbs...).